CHAPTER FIVE

CASE STUDY USING SITEONE IN RESTON

This chapter presents the collection and analysis methods for climatic, topographic, hydrologic, and vegetation data in Reston, Fairfax County, Virginia. The analysis procedures for climatic data include deriving hourly data from individual local weather stations, generating temperature and relative humidity data sets, interpolating point data to grid data, and applying related criteria to these data sets. Other data sets (topographic, hydrologic, and vegetation information) also need to be collected, converted to the desired format, and used to generate data sets. This chapter presents the analysis results from each individual category, as well as the overall outcome. Finally, the analysis procedures and sample result maps from SiteOne are described.

5.1 Case Study Using SiteOne

In order to test the proposed site analysis framework, a field study using SiteOne has been conducted in Reston, Virginia. The development of Reston, a planned community, integrating the physical appearance of roads, utilities and housing, as well as the social and economic aspects, began in 1962. Reston is located in Fairfax County, the most populated and densely developed suburban area outside the District of Columbia. In recent years housing demand has been increasing in Reston and neighboring towns. Fairfax County uses technology extensively to analyze information and communicate with the public. The county also maintains a large collection of digital maps[1]. More than 75% of County information is geographically referenced and analyzed (Fairfax Co.).

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[1] See the website of Fairfax GIS and Mapping Department for more information: http://www.co.fairfax.va.us/maps/map.htm.

The analysis tool first creates a selection matrix with five environmental components in the analysis concept module. Users can select one to five components in the analysis process. Secondly, the two analysis methods provided are contemporary principles and feng shui. The user can select either one or the other or both for further analysis. Thirdly, the tool offers two user-defined levels: the standard level, which includes default values for further analysis; and the expert level, which provides more choices in each module and its sub-categories. Finally, SiteOne uses the result generation module to investigate the relationships between housing sites and their surroundings. These relationships also derive a series of rankings and recommendations.

5.1.1 Study Area Selection

The town of Reston was selected to validate the proposed analysis framework, test the implementation of the framework using the SiteOne program, and demonstrate results for further application in a design process. The criteria considered in selecting Reston for the study area are as follows:

1. Reston's location and variety of housing make it an ideal place to test the SiteOne program. Located outside Washington, DC in Fairfax County, where detached single-family housing is the dominant type and housing costs are among the highest in the nation, Reston has, since its inception in 1962, provided housing for a variety of income levels. Since its development is carefully controlled, in spite of the increasing demand for housing, there is still limited amount of vacant land zoned for residential uses available for development.
2. Most data sets for Reston required for this research are available and accessible from Fairfax County. The county maintains a large collection of wall maps, aerial photographs, and digital maps (Tables 5-1, 2, 3). The county makes extensive use of technology, which plays an important role in analyzing information. County staff as well as the public can also use the online dynamic map system, called "time machine," to view aerial photography or search for a location based on address or parcel ID or locate the predefined "points of interest." GIS helps to reference and analyze more than 75% of County information geographically. The database

enhances the use of technology and decision-making, because digitized data can be updated and accessed on a daily basis.

3. Reston is located in a climate region with four well-defined seasons. It has overheating and underheating periods. This region also experiences both high and low humidity periods. It, therefore, has ideal climate conditions for a case study in this research.
4. Since the beginning of its development, Reston has been a focal point in media reports as well as in related academic research. The case study in this research emphasizes the physical environmental analysis of the residential development. It will become one of the key links in the physical aspects in the Reston research collection.

Table 5-1 Fairfax County aerial photographs

Fairfax County Aerial Photographs
▪ The 1937/43 and the 1953/54 photographs are available for viewing/research purposes. ▪ Copies are available for aerial photographs in even years 1968-1990 and 1994-1998.

5.1.2 Introduction of Reston, VA

Reston, Virginia is the nation's best known and most successful Planned Community, or, "New Town," as it is often called. The founding in 1962 marks the beginning of the current era of New Town development. Today's Reston is the result of the vision of Robert E. Simon, Jr. and the Mobil Corporation. Reston, which provides the model for other New Towns, integrates not only the physical appearance of roads, utilities and housing, but also the social and economic aspects, including education, health care, recreation, civic organizations, and industrial and commercial centers. In addition, it provides housing for a variety of income levels and allows residents to participate in governing the town.

Table 5-2 Fairfax County wall map series

Fairfax County Wall Maps Series
▪ Property Maps (1" = 500' or 1"=200') ▪ Zoning Maps (1"=200') ▪ Contour Maps (1" = 500' or 1"=200') ▪ Topographic Maps (1" = 500' or 1"=200') ▪ Soils Maps (1" = 500') ▪ Chesapeake Bay Preservation Areas Maps (1" = 500') ▪ Flood Plain Delineation Maps (1" = 100') <u>1" = 4000' scale map series:</u> ▪ Cemeteries Sites ▪ C.H.A.S. Housing and Community Development ▪ Commercial and Industrial Development ▪ Countywide Trails Plan ▪ Elementary School Attendance Areas ▪ Fire and Rescue Department Assignment Box System ▪ High School Attendance Areas ▪ Historic Sites Inventory ▪ Land Patents and Northern Neck Grants ▪ Middle School Attendance Areas ▪ Office and Industrial Zoning ▪ Planning Districts ▪ Postal Zip Codes ▪ Public Facilities ▪ Public Parks ▪ Public Schools ▪ Radon Potential ▪ Solid Waste Refuse Collection and Recycling ▪ Sanitary Sewers ▪ Sewersheds ▪ Streets - 3 colors (black, blue, red) with tax grid ▪ Streets - 3 colors (black, blue, red) with tax grid and yellow tint ▪ Streets - 3 colors (black, blue, red) with yellow tint ▪ Streets - black & white ▪ Streets - black & white with tax grid ▪ Sub Census Tracts with Planning Districts ▪ Sub Census Tracts with Supervisor Districts ▪ Supervisor Districts ▪ Transportation Plan ▪ Utilities Water and Gas ▪ Volunteer Groups ▪ Voting Precincts ▪ Watersheds

Table 5-3 Fairfax County digital maps

Property
▪ Address Grid (gridadd) ▪ Agricultural and Forestal Districts (agfor) ▪ Common Areas (common) ▪ Easements (esmt) ▪ Flood Plains (flood) ▪ Miscellaneous Property lines (pmiscline) ▪ Miscellaneous Property points (pmiscpt) ▪ Parcel Boundaries (parcel) ▪ Planning Areas (plan) ▪ Political Jurisdiction Boundaries (pol) ▪ Questionable Parcel Cuts (illegal) ▪ Right of Way (row) ▪ Special Tax Districts (spctax) ▪ Subdivisions (sbdv) ▪ Subdivision Blocks (block) ▪ Wetland Areas (wetlandp) ▪ Wetland lines (wetlandl) ▪ Zoning (zoning) ▪ Zoning Case Applications (case) ▪ Zoning Case Applications Prior to 2000 (zcasept) ▪ Zoning Overlay Districts (zodist)
Contour
▪ Contours (contour) ▪ Spot Elevations (spot)
Planimetric
▪ Airport Facilities (airport) ▪ Building Outlines (bldg) ▪ Community Pools (commpool) ▪ Geodetic Control Points (control97) ▪ Hydrography lines (hydrol) ▪ Hydrography polygons (hyrdop) ▪ Major Transportation (transmaj) *Edge of road pavement* ▪ Minor Transportation (transmin) *Edge of parking lot pavement* ▪ Railroads (railroad) ▪ Sidewalks (sidewalk) ▪ Street Centerline Network (stcline) ▪ Tax Map Grid (gridtax) ▪ Utility Facilities lines (utilityl) ▪ Utility Facilities points (utilitypt)

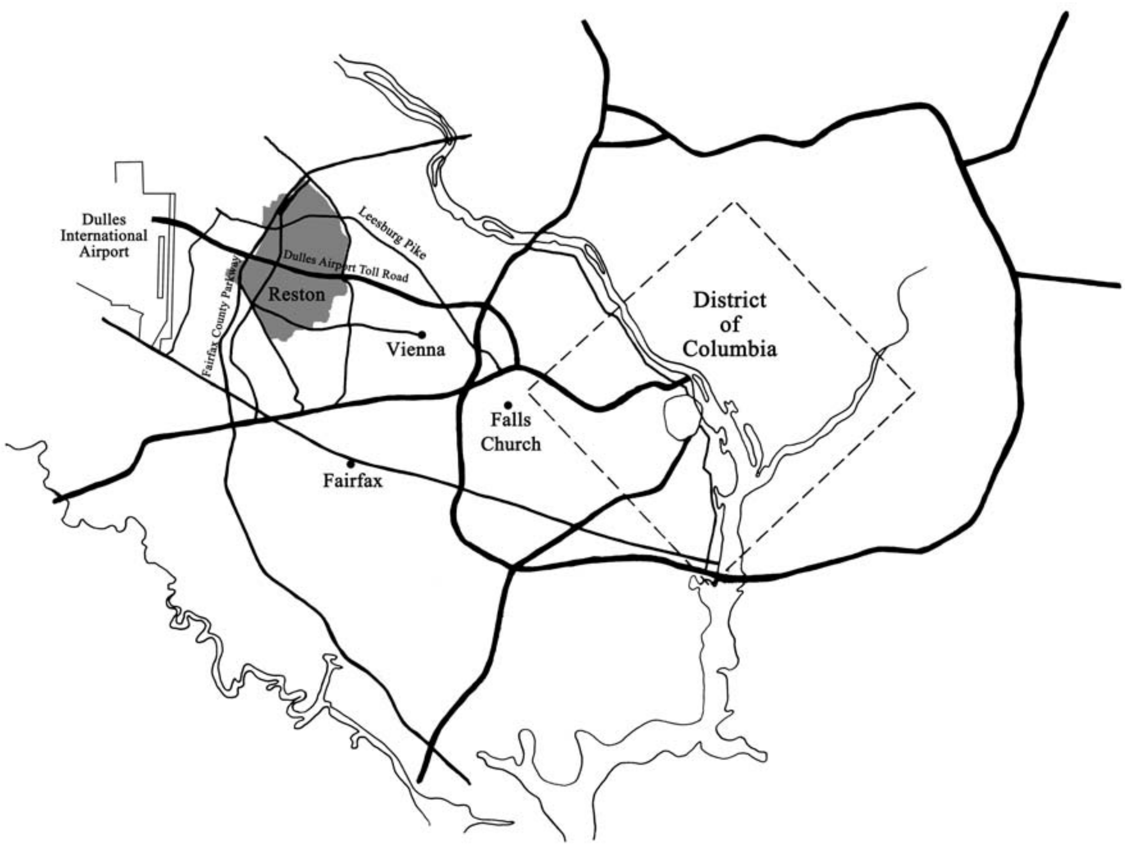

Figure 5-1 Reston location map

Location

Located eighteen miles west of Washington, DC. and four miles east of the Washington Dulles International Airport in Fairfax County, Virginia (Figure 5-1), Reston covers 7,400 acres or 11.5 sq. miles. Three major roads connect the town to Washington, Dulles Airport, and other towns in Fairfax County: Leesburg Pike (State Route 7), Dulles Airport Toll Road, and Fairfax County Parkway (State Route 7100).

Geology

In general, the soils of the entire Reston area are suitable for construction, except for the small portion of shallow hard rock on the western edge. Dark-colored diabase rocks cover other parts of the western edge of Reston on the surface. The soils of this area are Triassic Diabase and Syenite rock soil group. The Piedmont Schist soil-rock group, which covers the largest portion of Reston, is mostly in the eastern part and, therefore, makes this area desirable for both urban development and agricultural use (Figure 5-2).

Topography

The elevation of Reston ranges from 237 feet above sea level in the east to 479 feet in the west. Most of the area has gentle slopes of less than 10%, and no area has a slope of greater than 43% (Figure 5-7). Reston is located in two major watersheds: on the west, in Sugarland Run; and on the east, in Difficult Run, which brings the principal water courses from Piney Run, Colvin Run, Snakeden Branch, and the Glade.

Climate

Reston has a continental climate with four well-defined seasons: warm, humid summers, mild winters, and pleasant springs and falls. The annual mean air temperature, measured at Washington Dulles International Airport, is about 54 °F. In the coldest January, the mean minimum temperature is 22 °F, and in the warmest July, the mean maximum is 87 °F. Precipitation is evenly distributed throughout the year, except when there is a drought such as has occurred over the last few years. Long-term annual precipitation ranges from about 29 inches to 59 inches, with an average of 40.8 inches. Annual snowfall is 21.5 inches (Table 5-4).

Prevailing winds are from the northwest in the winter, and from the south in other seasons. Late winter and early spring normally have the windiest days. During severe weather conditions, such as summer thunderstorms, hurricanes, and winter storms, the wind speed can reach 60 miles per hour or higher.

Table 5-4 Reston climate summary[2]

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Mean Temperature (^{o}F)	31.5	34.4	43.3	53.2	62.4	71.2	75.8	74.4	67.1	55.1	45.3	36.0	54.1
Mean Minimum Temperature (^{o}F)	22.0	24.1	32.0	40.7	50.2	59.4	64.4	63.0	55.4	42.4	34.1	26.4	--
Mean Maximum Temperature (^{o}F)	41.0	44.8	54.5	65.6	74.6	82.9	87.2	85.8	78.7	67.7	56.6	45.6	--
Precipitation (in.)	3.0	2.7	3.5	3.0	4.0	4.0	3.6	3.9	3.7	3.1	3.2	3.1	40.8
Snowfall (in.)	7.1	6.2	3.5	0.3	0.0	0.0	0.0	0.0	0.0	0.0	1.0	3.4	21.5

[2] Monthly weather surface data from Washington Dulles International Airport can be obtained (WBAN ID: 93738) at: http://lwf.ncdc.noaa.gov/oa/climate/stationlocator.html

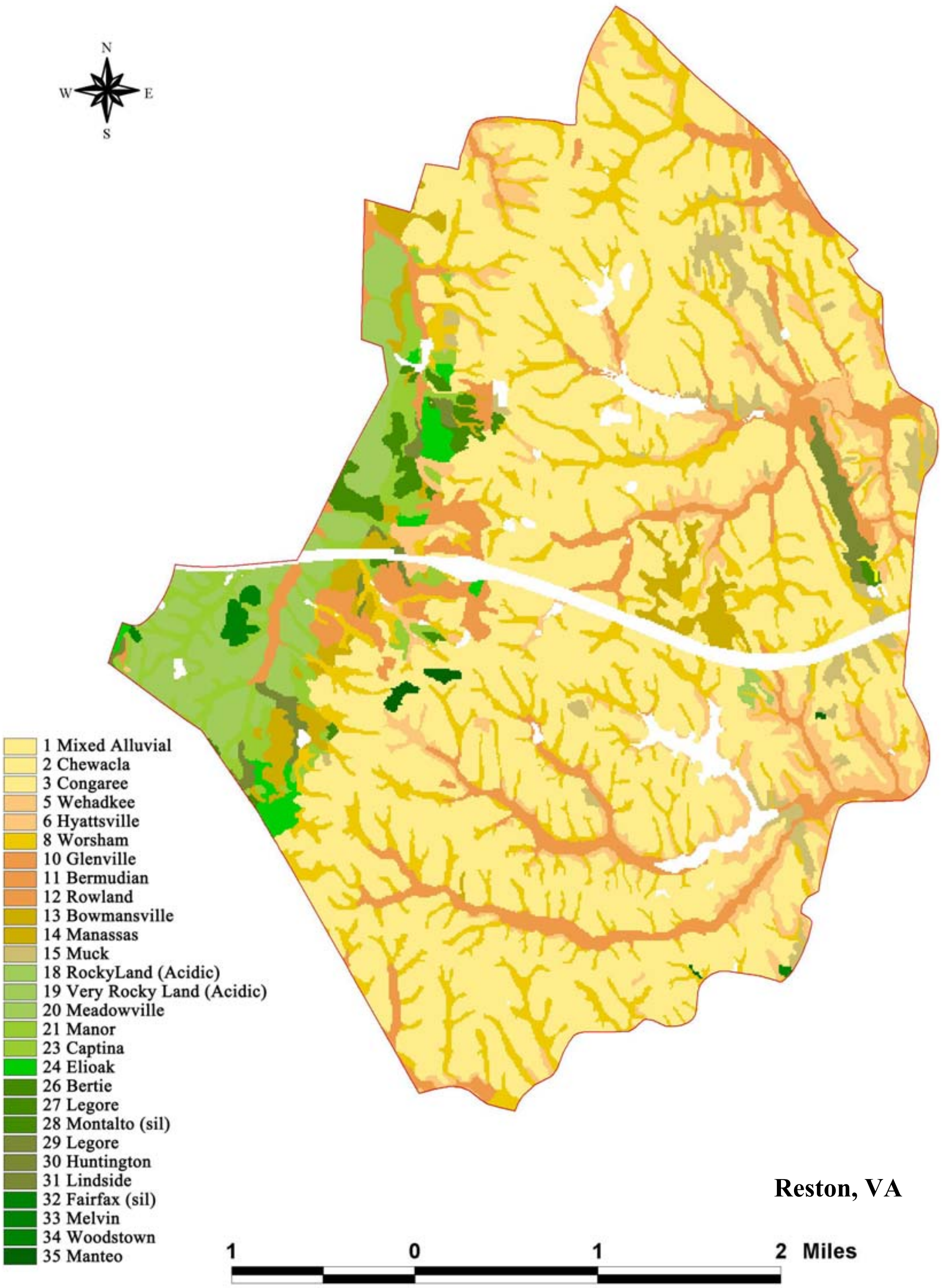

Figure 5-2 Reston soil type map

Zoning

The original zoning regulations for Reston were innovative. The developers planned seven villages, each including low, moderate, and high-density housing, and a center for shopping, religious usage, and recreation. The master plan separates industry and business from housing. It also includes fifteen elementary schools, six intermediate schools, three high schools, and one community college (Simon, 1963). Since 1978, new development has added additional schools and parks, a regional county branch library, a hospital, a shelter for the homeless, a county magisterial district office building, and a nursing center for the elderly (Figures 5-3 and 5-4).

5.1.3 SiteOne Applications

With its analysis modules, methods, and levels, SiteOne can graphically provide the analysis output to show the preferable housing sites in Reston based on user input. Since users can also prioritize their wants and needs in the analysis process, the results can indicate advantages, disadvantages, and desirability of the selected sites, and finally generate rankings of these alternatives.

The SiteOne program in this case study demonstrates the importance of site selection and evaluation for housing. It provides an important background for environmental integration that may result in energy savings. SiteOne enables designers to emphasize housing affordability through energy efficiency and environmental integration. As a result of applying such principles, first cost and utility expenses might be lower, thus increasing house affordability for low-income families.

Consideration of environmental issues not only benefits the homeowners, but also provides opportunities for improving "green" effects and sustainable growth. From the output, a series of recommendations and rankings offer the possible integration of sustainability into planning and architectural practice. With less energy usage and more natural system integration, the results can improve indoor living conditions, enhance the concept of community renewable energy, and further decrease environmental damage caused by erosion and water run-off.

Analysis of the environmental conditions of the selected region helps individual home buyers, small to large developers, regional planners, and policy-makers to better understand

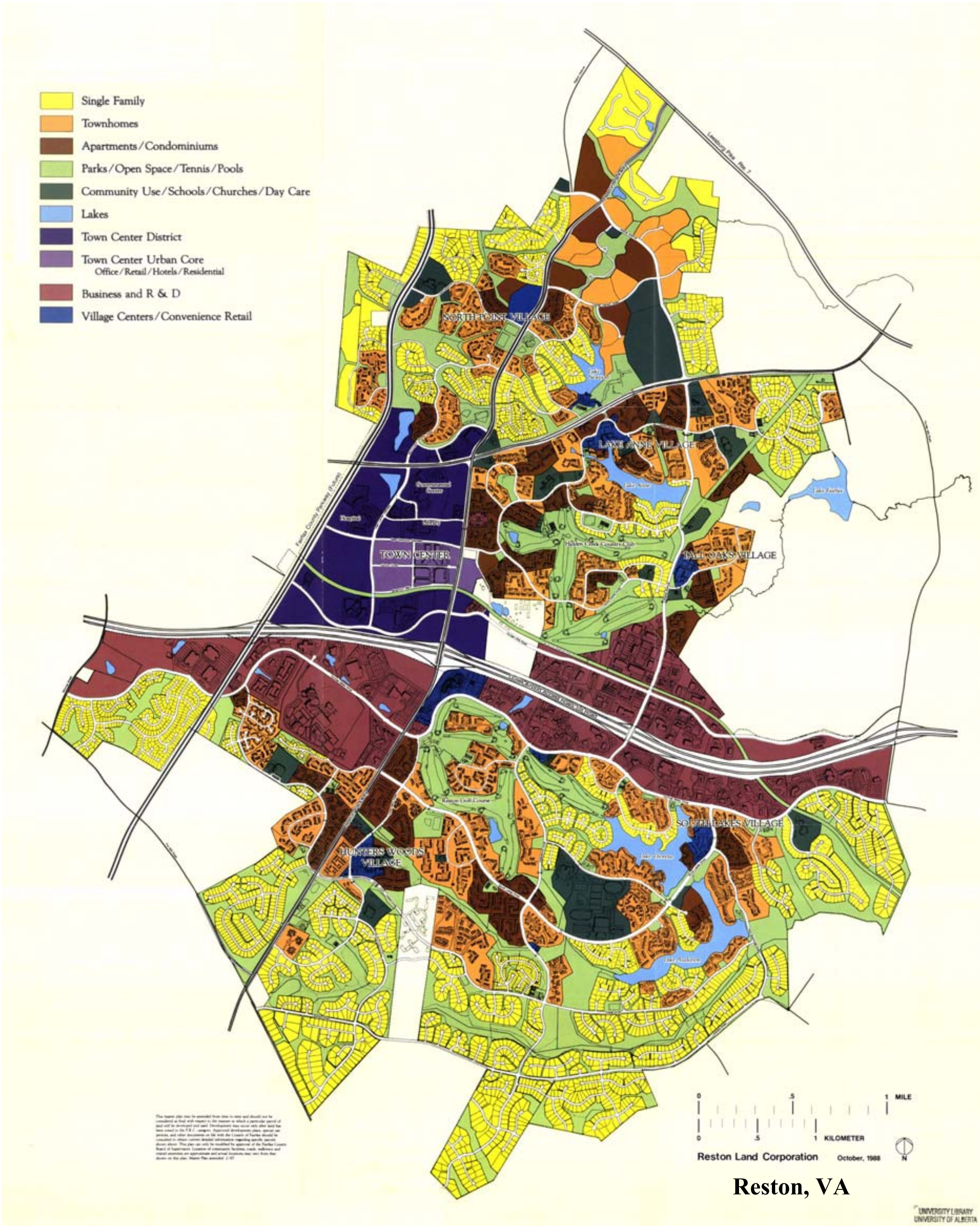

Figure 5-3 Reston master plan (1988)

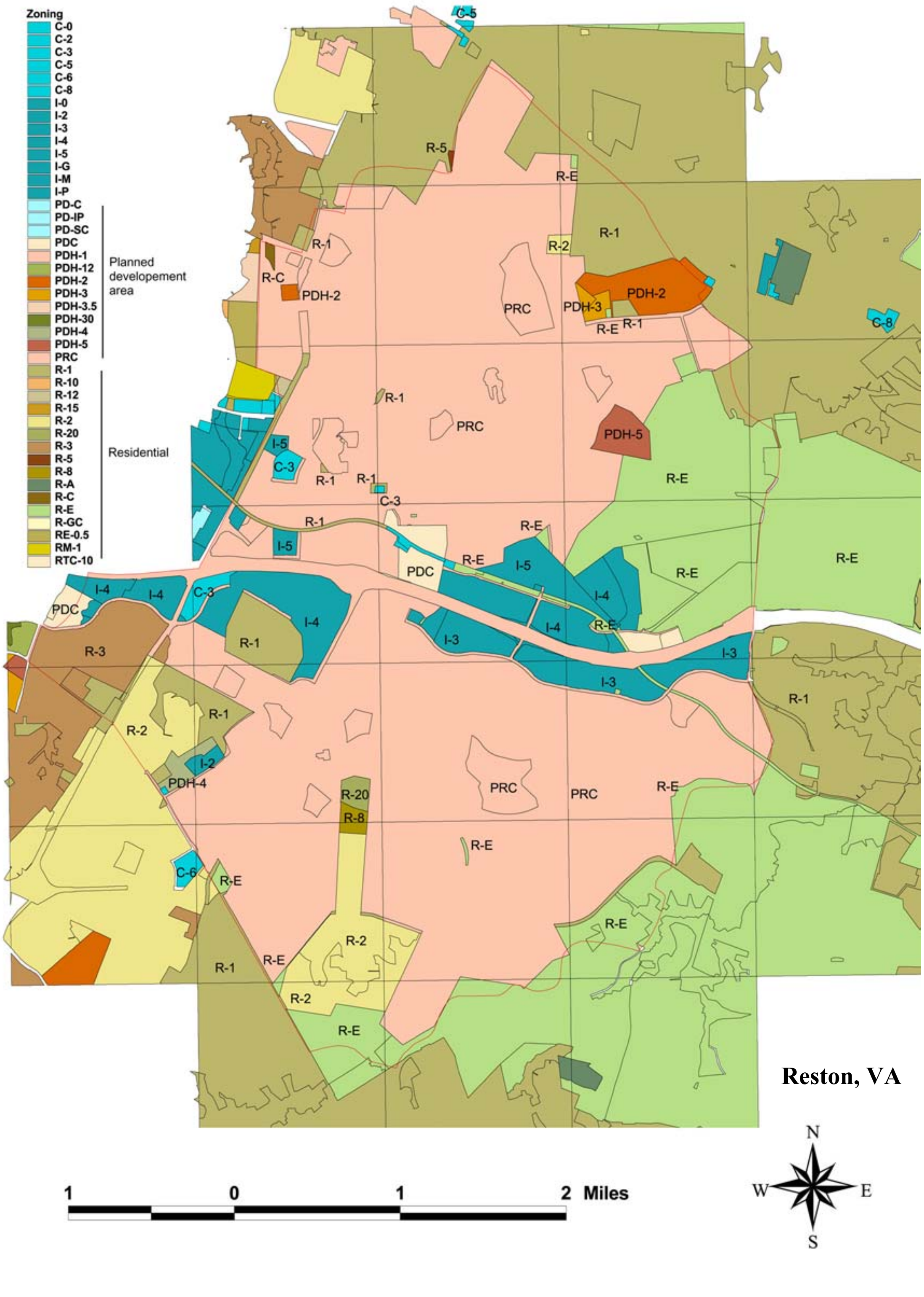

Figure 5-4 Reston zoning map (from Fairfax Co. 2002)

different impacts. The analysis process and results can increase the residents' involvement and improve "community development" with a common background.

5.2 Topographic Data

5.2.1 Data Collection and Preparation

Three topographic data sets of Fairfax County are available: an elevation point map, a contour map, and a digital elevation model (DEM). The DEM data is ideal for topographic analysis; however, the available DEM data sets are derived from high-resolution satellite imagery using the United States Geological Survey's 7.5-minute topographic quadrangle maps. Each elevation cell represents an area measuring 30 meters by 30 meters. This area is almost twice the size of the cells (50 ft. by 50 ft.) used by other data sets in this research. The DEM data also has a different projection[3] than that of other data sets. Therefore, the elevation contour map is used as the base map to derive the desired data sets for the topographic, climatic, and hydrologic analyses. The elevation point map and the DEM data help to validate the maps that are generated by GIS functions and techniques (Figure 5-5).

Generating the elevation grid data set from the contour map is a two-step process. In the first step, a triangulated irregular network (TIN) map is created from the contour map. TIN models represent topography with contiguous and non-overlapping triangles, each of which has three nodes, three lines, and a face with unique slope and aspect values. The vertices in the contour lines become triangle nodes, and each one has the same elevation value as the others in the same contour line. The contour lines have been clipped from the elevation contours for all of Fairfax County. Then, a TIN map is generated from the contour map.

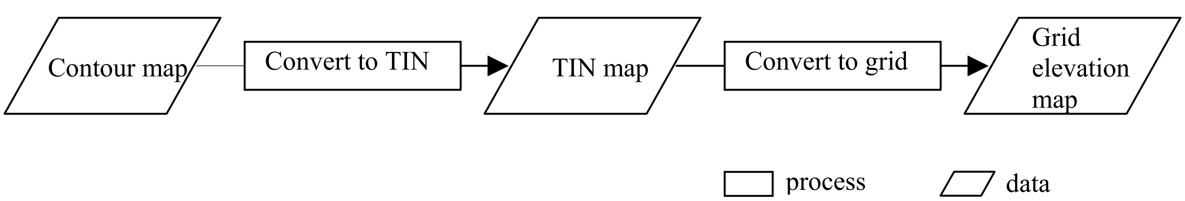

Figure 5-5 Flowchart for creating an elevation grid map

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[3] Projection is a mathematical calculation that transforms the three dimensional surface of the earth to a two-dimension plane.

The second step is to create an elevation grid map from the TIN map through the use of the ArcView GIS function. The conversion calculates the elevation of each cell (50 ft. by 50 ft.). After this process, the elevation grid map (Figure 5-6) is ready for further analyses. It shows that the elevation of Reston ranges from 237 to 479 feet above sea level.

The elevation grid map can be used to generate a slope map. The output grid indicates the slope by percentage or in degree. For example, a 100% slope corresponds to 45˚. The percentage of slope approaches infinity as the slope approaches vertical (90˚). In this research, an output grid indicating slope as a percentage is more appropriate because the slope criteria used by McHarg, Lynch, and Hendler are percentages instead of degrees. Figure 5-7 shows the resulting slope map. The values are classified and shown in shades of gray. Most of the case study area has gentle slopes of less than 10%, and no area has a slope of greater than 43%.

The elevation grid map can also generate the aspect map (Figure 5-8). The aspect map shows the orientation of slopes in degrees for eight directions. The orientation starts from 0° north and increases clockwise. There are eight directions, each of which cover a 45° arc. For example, an east orientation corresponds to directions between 67.5° and 112.5°.

In addition, the elevation grid map can generate a hillshade map that indicates the surface illumination when the sun is at a specific position in the sky. This research uses the sun's position on September or March 21 to analyze the hillshade (next section). Each cell of the hillshade map is assigned a value between 0 and 255, equivalent to a shade of gray.

5.2.2 Map Generation

Further topographic analysis uses the elevation, slope, aspect, and hillshade maps created in the previous steps. The elevation grid map can generate two maps used in topographic analysis in feng shui. The "peak" map highlights the areas that have elevations higher than 451 feet above sea level; while the "lowest" map shows the results if the elevation is lower than 255 feet above sea level.

Three interval scale criteria apply to the slope map. SiteOne shows different results if the slope is greater than 4% ("slope4" map, Figure 5-9), less than 10% ("slope10" map, Figure 5-10), or less than 16% ("slope16" map, Figure 5-11). Feng shui analyses use the results in the "slope4", river, wetland, floodplain, and lower land maps to identify potential flooding areas. These areas are most likely located in a flat area (with less than 4% slopes) near a body of water, or in lower land, wetland, and floodplain (Section 5.4). With the consideration of elevation, hillshade, and aspect, the results in the "slope10" map are also important for feng shui analyses as they help to identify favorable topographic features (Figure 4-11).

This research needs several aspect maps according to different modes selected by users. For example, the preferred orientation for feng shui ("asp_esw" map) from east to southwest corresponds to directions between 67.5° and 247.5° (Figure 5-12). The preferred orientation for contemporary environmental design principles is from northeast to northwest. The result "asp_nenw" map is used. The "asp_nw" map indicates the northwest orientation from 292.5° to 337.5°, the direction that the prevailing winter wind comes from (Figure 5-13).

Feng shui analysis uses three hillshade maps to identify areas that are shadowed. In these hillshade maps, the sun's azimuth angles are 110° (southeast), 180° (south), and 250° (southwest). The sun's corresponding altitude angles are 23° (8 o'clock), 50° (12 o'clock), and 23° (16 o'clock) on September or March 21 in Reston (Brown and DeKay, 2001). Because the highest areas identified from the elevation maps have values that range from 97 to 164 in the hillshade maps, the values of 97 and 164 are set as criteria for hillshade analyses. The colored squares in the overall "shadow" map are favorable areas that are not shadowed in any two of the hillshade maps (Figure 5-14).

Both feng shui and contemporary environmental principles use these derived maps for topographic analysis. Figure 4-11 shows the flowchart of default settings using feng shui. The result "fs_topo" map comes from five sub-composition maps, including elevation analysis maps ("lowest" and "peak" maps), hillshade ("shadow" map), slope ("slope10" map), and aspect maps ("asp_esw" map). Cells in each map are assigned a value of either 0 or 1, depending on whether the original value meets the criteria for each map. The colored squares in each map, which have the value 1, are favorable, while the uncolored ones are unfavorable. For example, the uncolored areas in the "lowest" map indicate the lower areas, while those that are uncolored in the "peak" map indicate the hilltops. If a cell in any of the five maps is not equal to one, then the piece of land that it represents is not favorable.

Therefore, summing up the values for each of the five maps creates an overall result map (Table 5-5, Figure 5-15).

Table 5-5 Method of overlay for topographic analysis using feng shui

Map name	Value in the cell	Criteria
lowest	0 / 1	Lowest areas / Others
peak	0 / 1	Peak areas / Others
shadow	0 / 1	Shadow areas / Others
slope10	0 / 1	Steep slopes / Gentle slopes
asp_esw	0 / 1	West, northwest, north, northeast / East, southeast, south, southwest
fs_topo	**5 = most favorable, otherwise unfavorable**	**Sum of values**

Contemporary environmental principles use a similar process to analyze topographic features. The result map for default setting comes from both the slope and aspect maps (Figure 4-10). Favorable slopes should be less than 16%, and the preferred orientation is ranging from northeast to northwest (Hendler, 1977). Therefore, the analysis uses the "slope16" map and the "asp_nenw". The colored areas in the result "ce_topo" map indicate the areas that meet both criteria (Figure 5-16).

5.3 Climatic Data

In this research, the only data sets that need to be collected and managed from observation data sets are climatic data sets. Therefore, climatic data management includes collecting data from each of the selected 45 weather stations, storing data sets, converting data into hourly data sets that cover all stations, generating descriptive maps for each climatic factor, and applying the different criteria to obtain result maps (Figures 4-4, 4-5, and 4-6). The following sections describe in detail how each step uses different computer software packages to collect and generate the desired data sets.

5.3.1 Data Collection

This research collects climatic data sets from 45 weather stations both inside and around Reston, the study area (Figure 5-17). These weather stations are located across 240,000 acres, an area 32 times bigger than Reston. The data sets use hourly observation

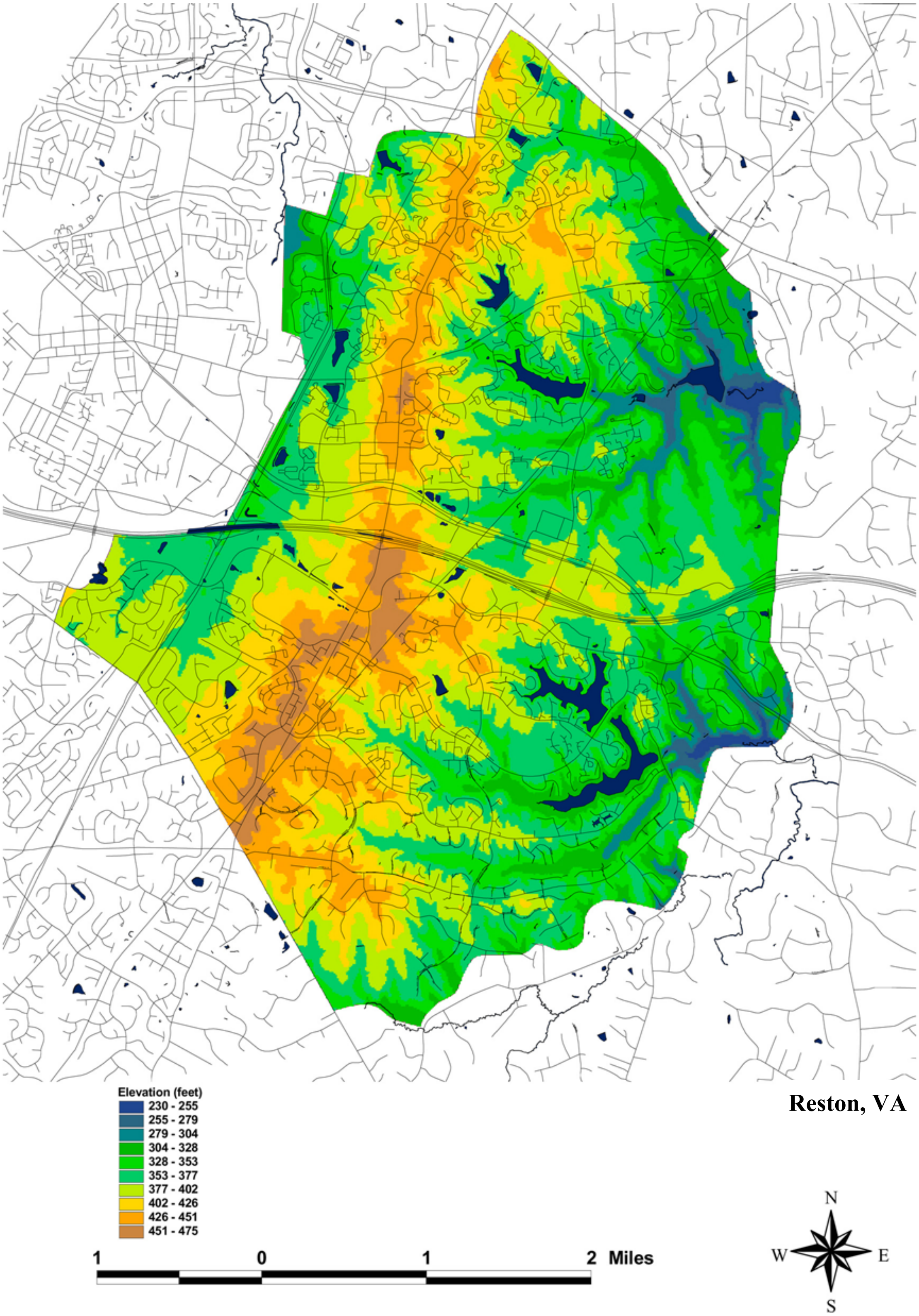


Figure 5-6 Elevation grid map

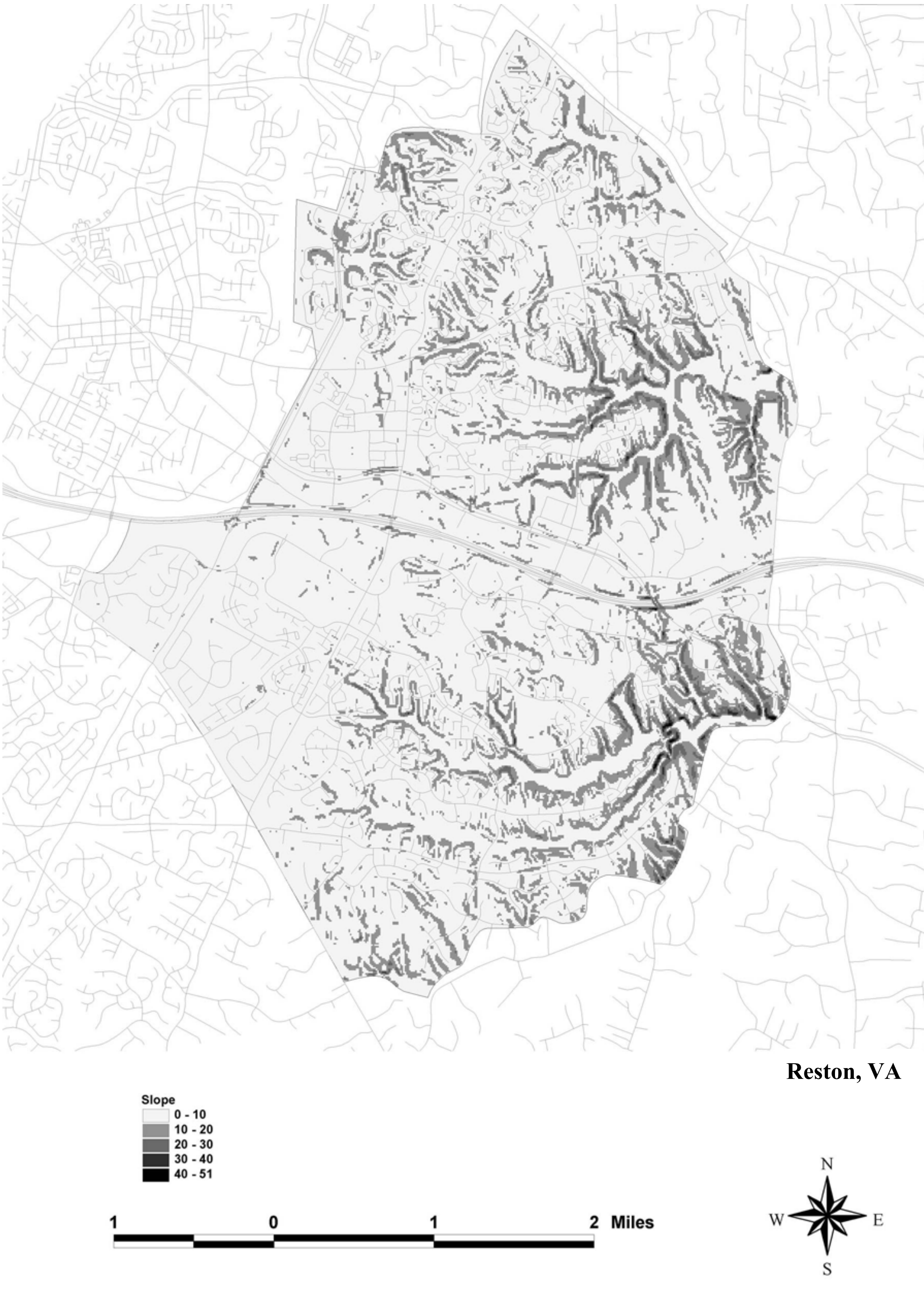


Figure 5-7 Slope map

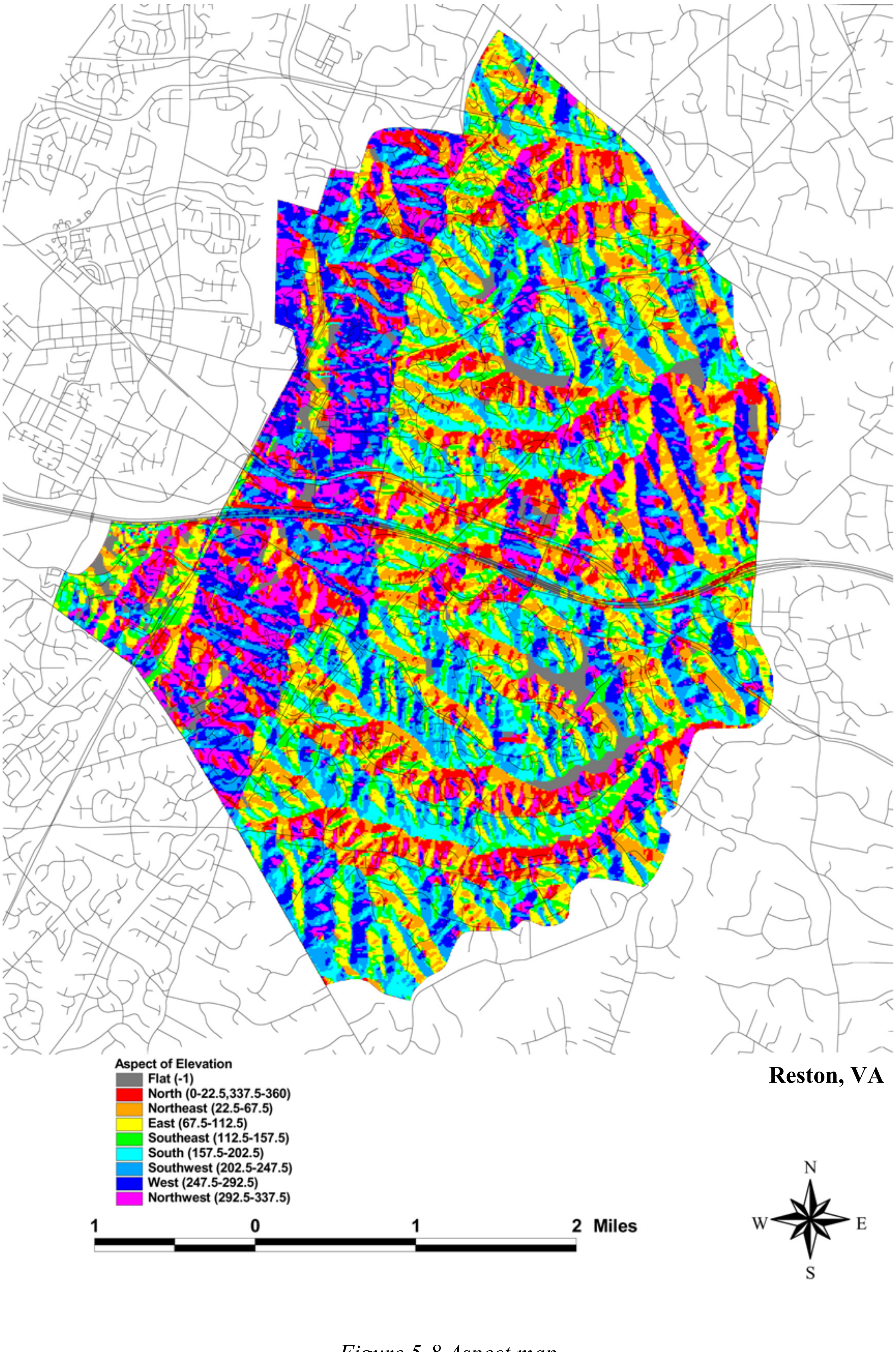


Figure 5-8 Aspect map

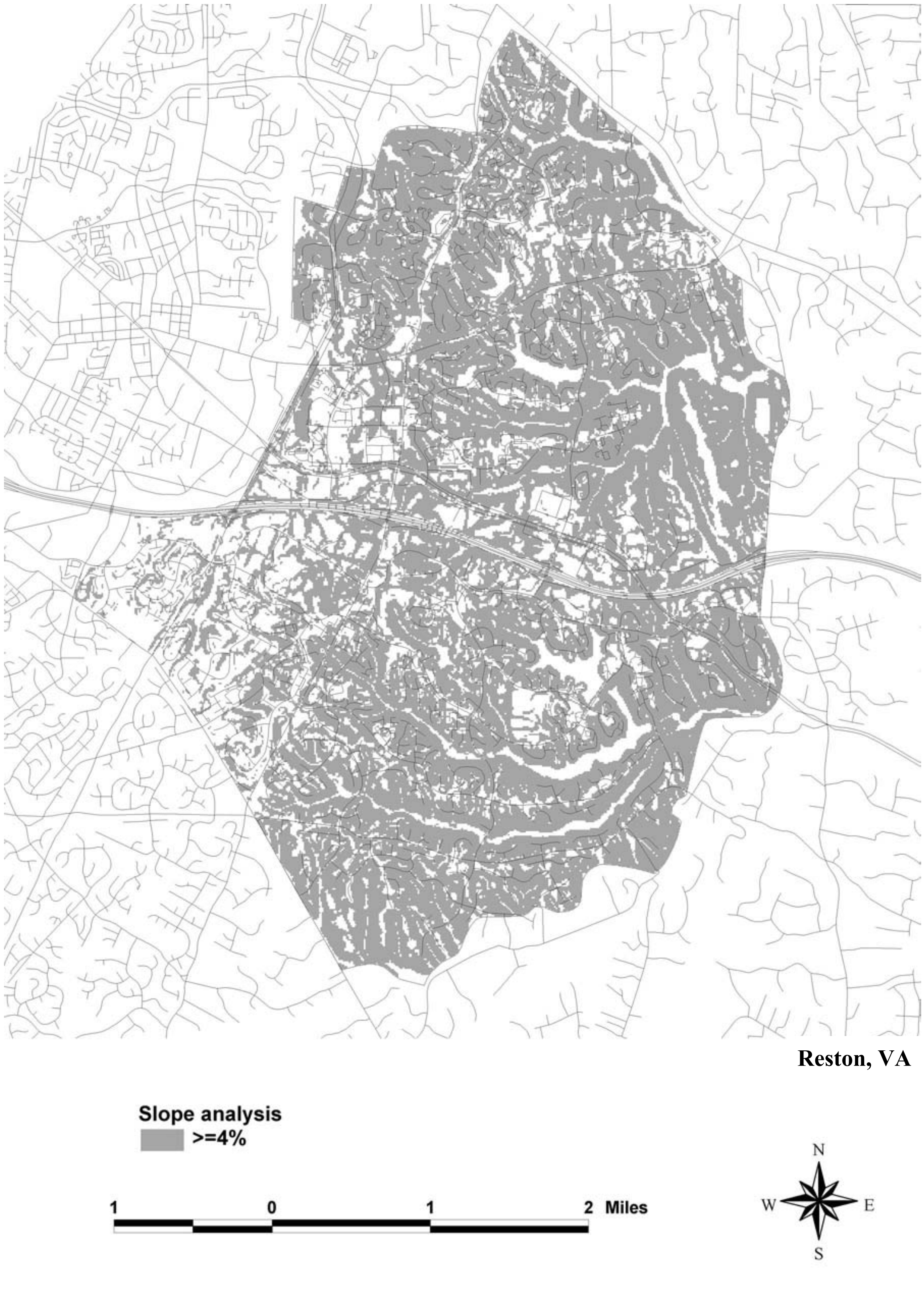


Figure 5-9 "slope4" map

Figure 5-10 "slope10" map

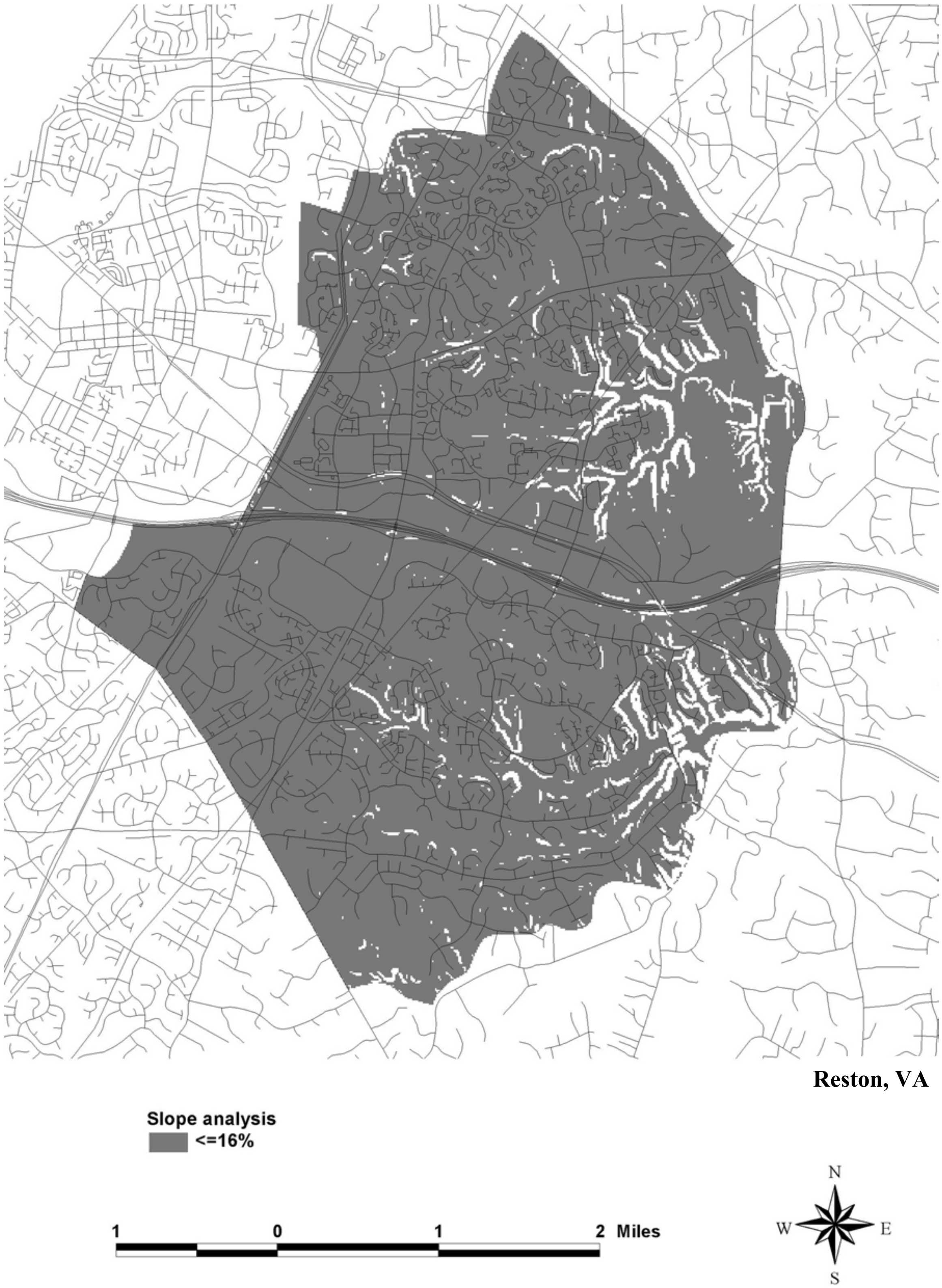


Figure 5-11 "slope16" map

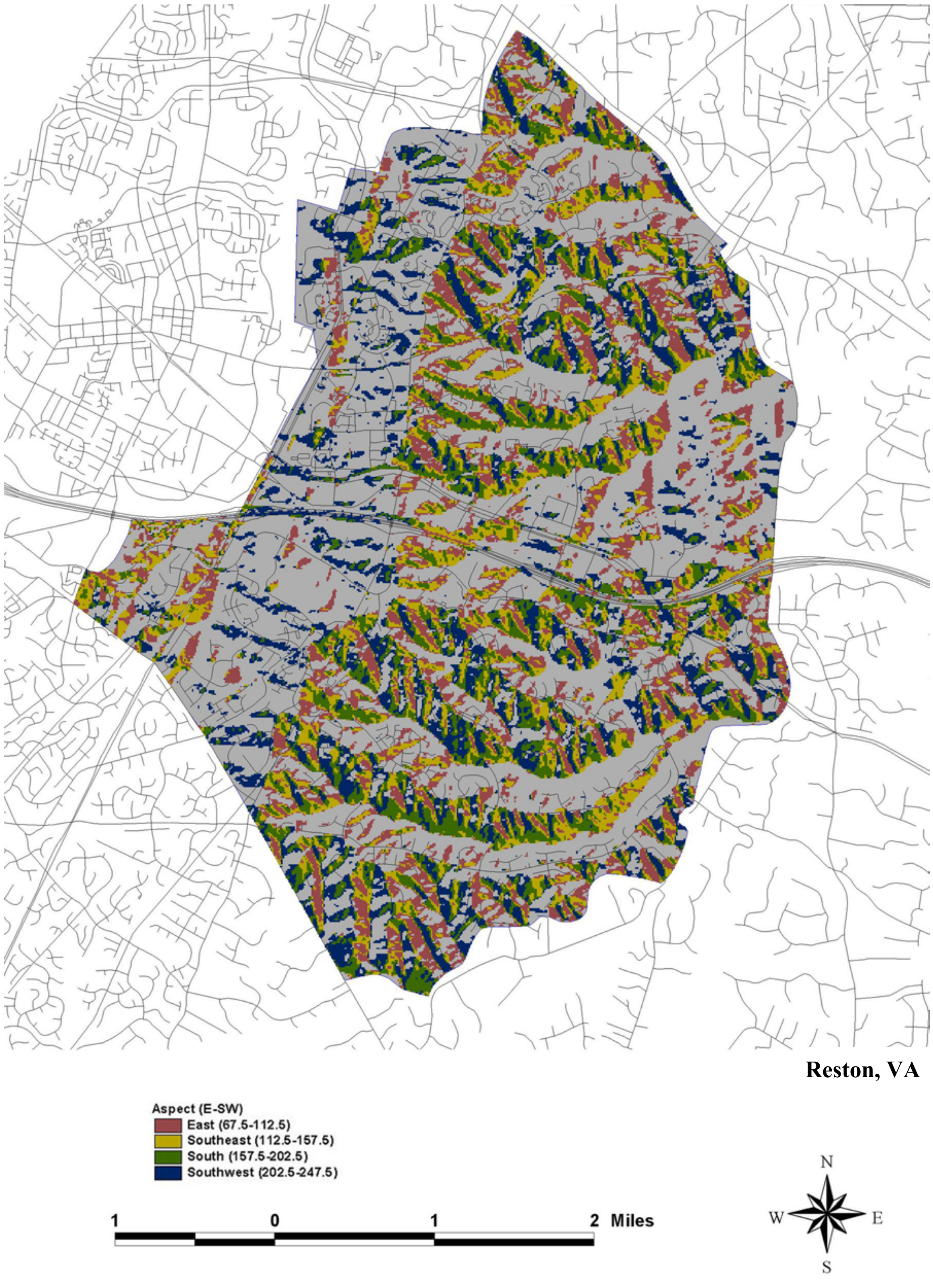


Figure 5-12 "asp_esw" map

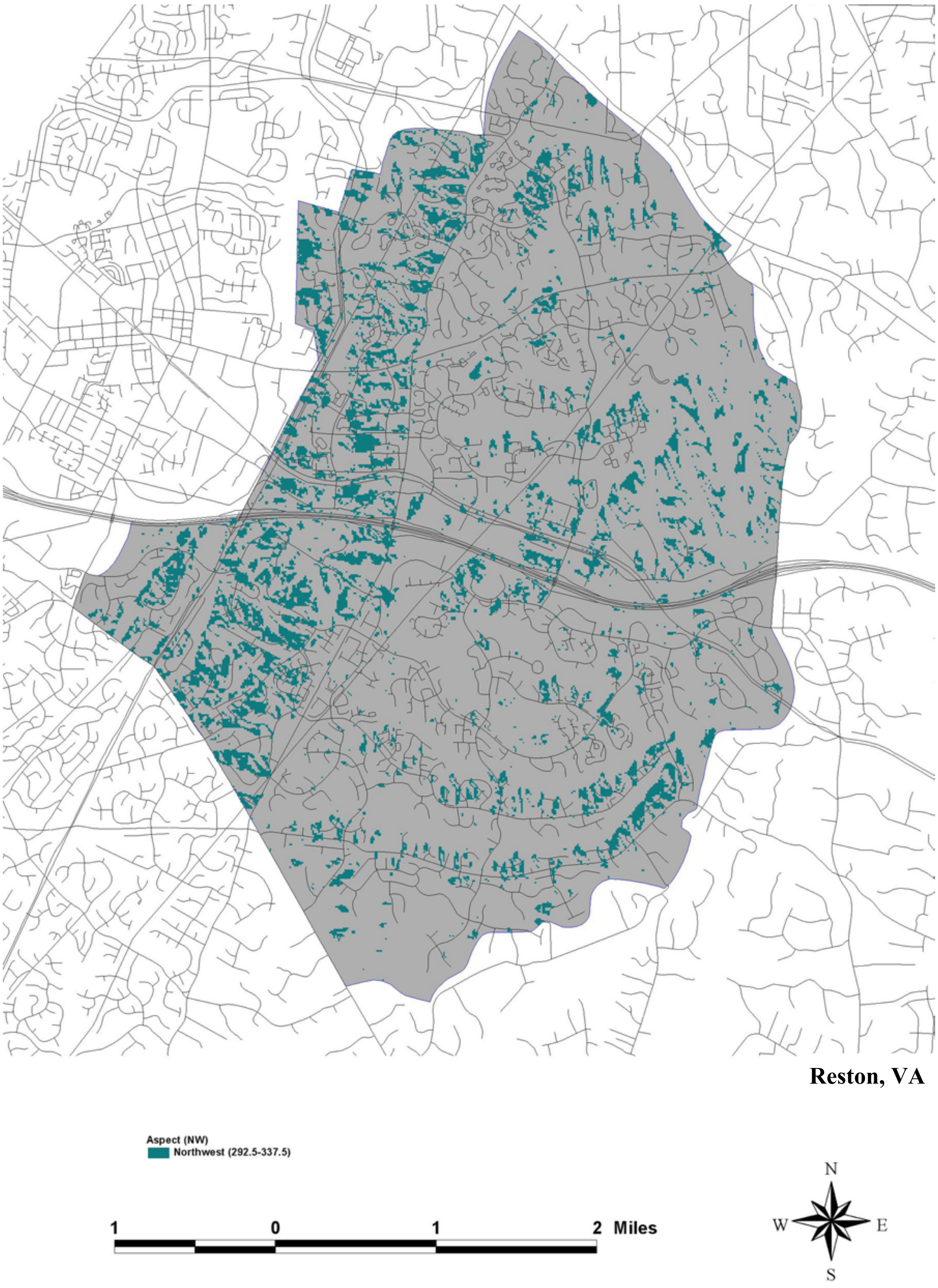


Figure 5-13 "asp_nw" map

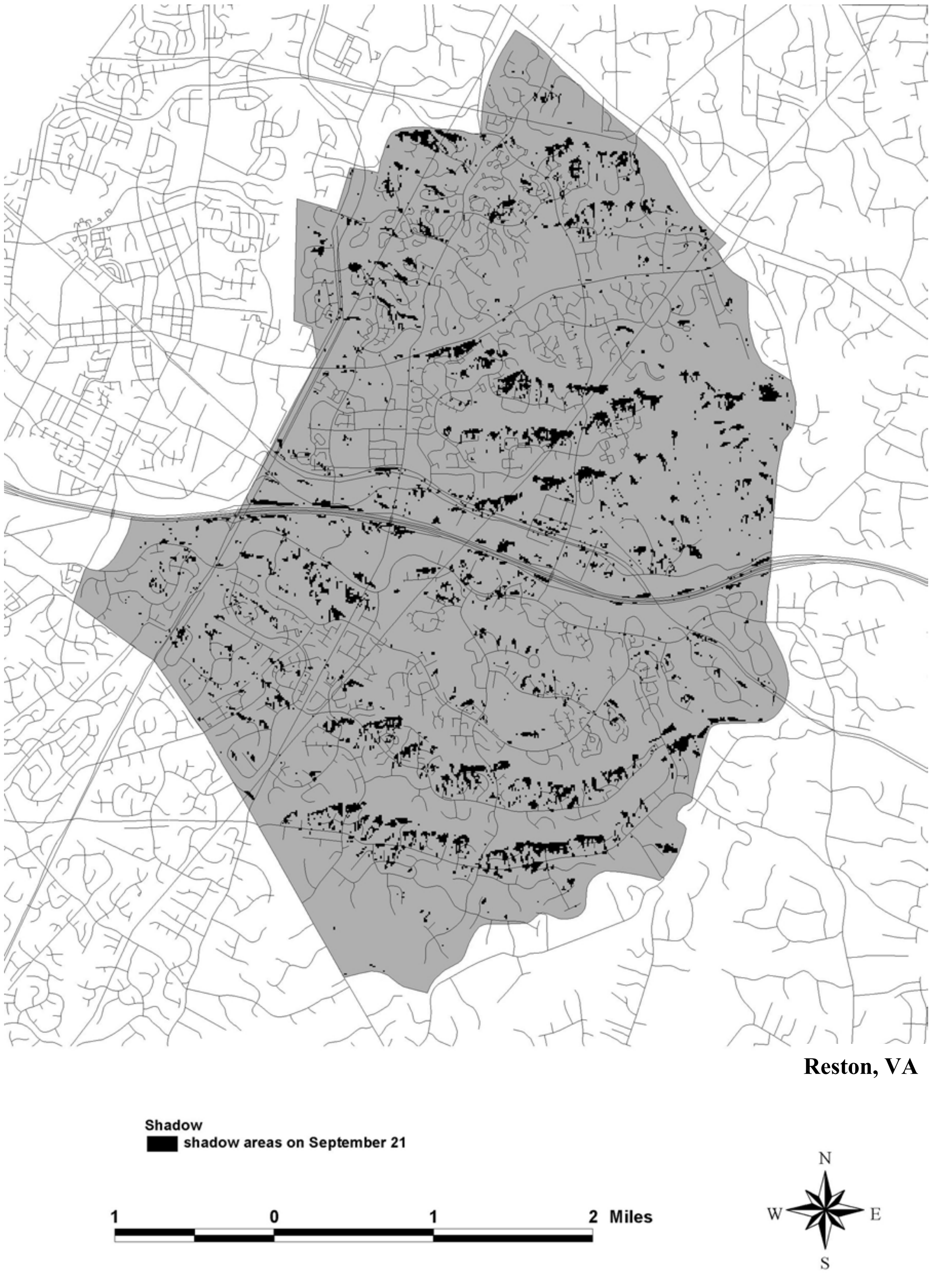


Figure 5-14 Hillshade "shadow" map

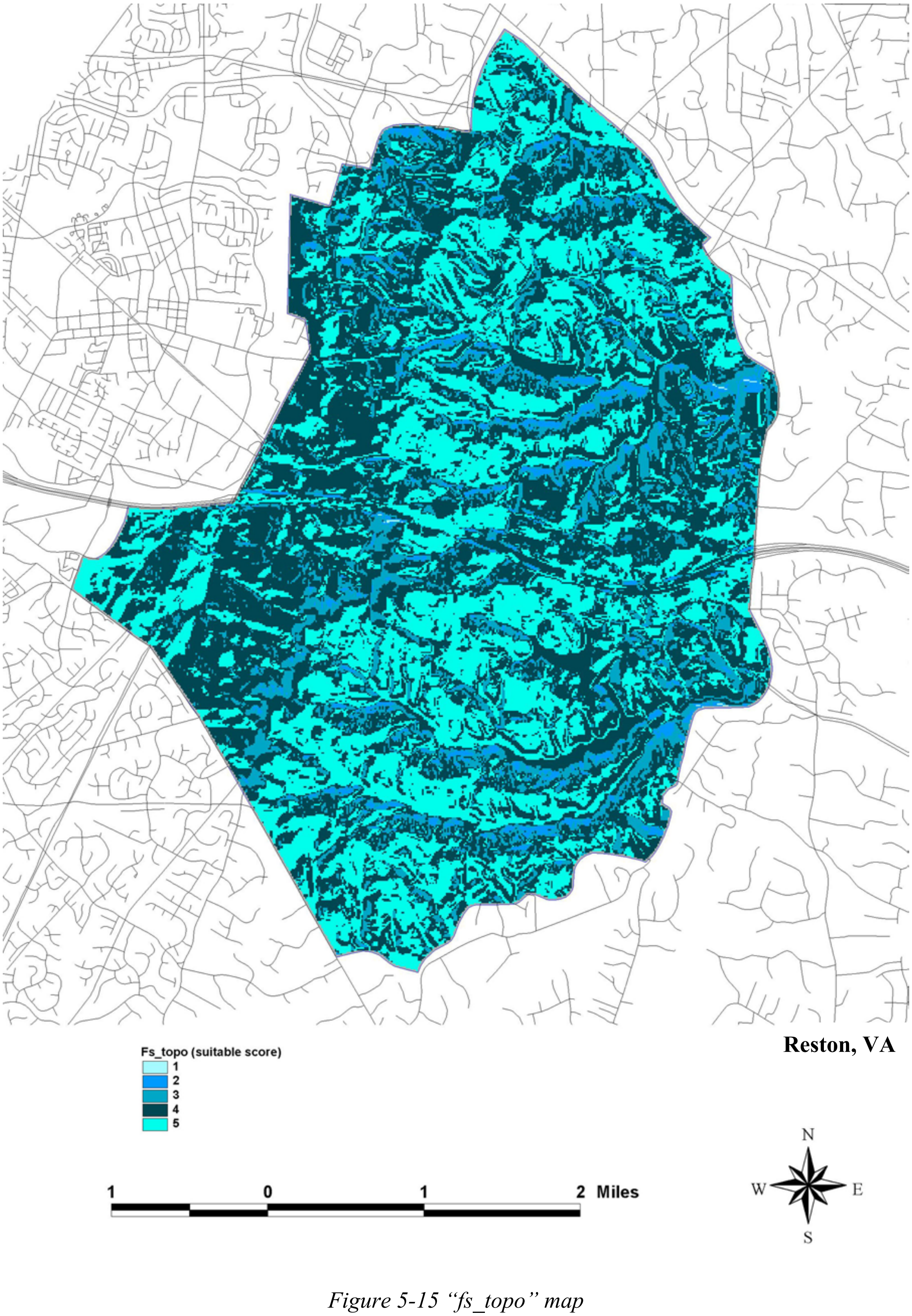


Figure 5-15 "fs_topo" map

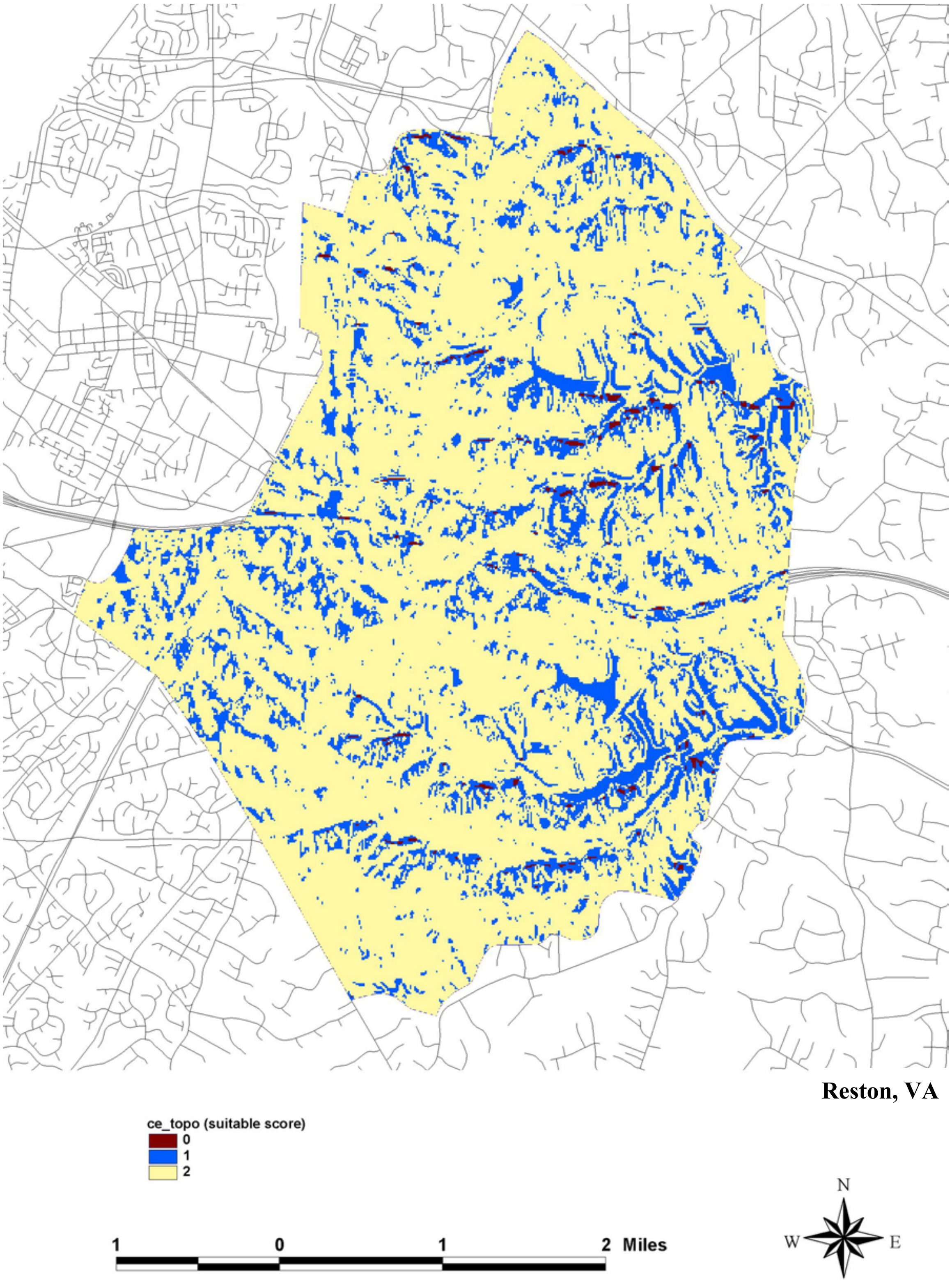


Figure 5-16 "ce_topo" map

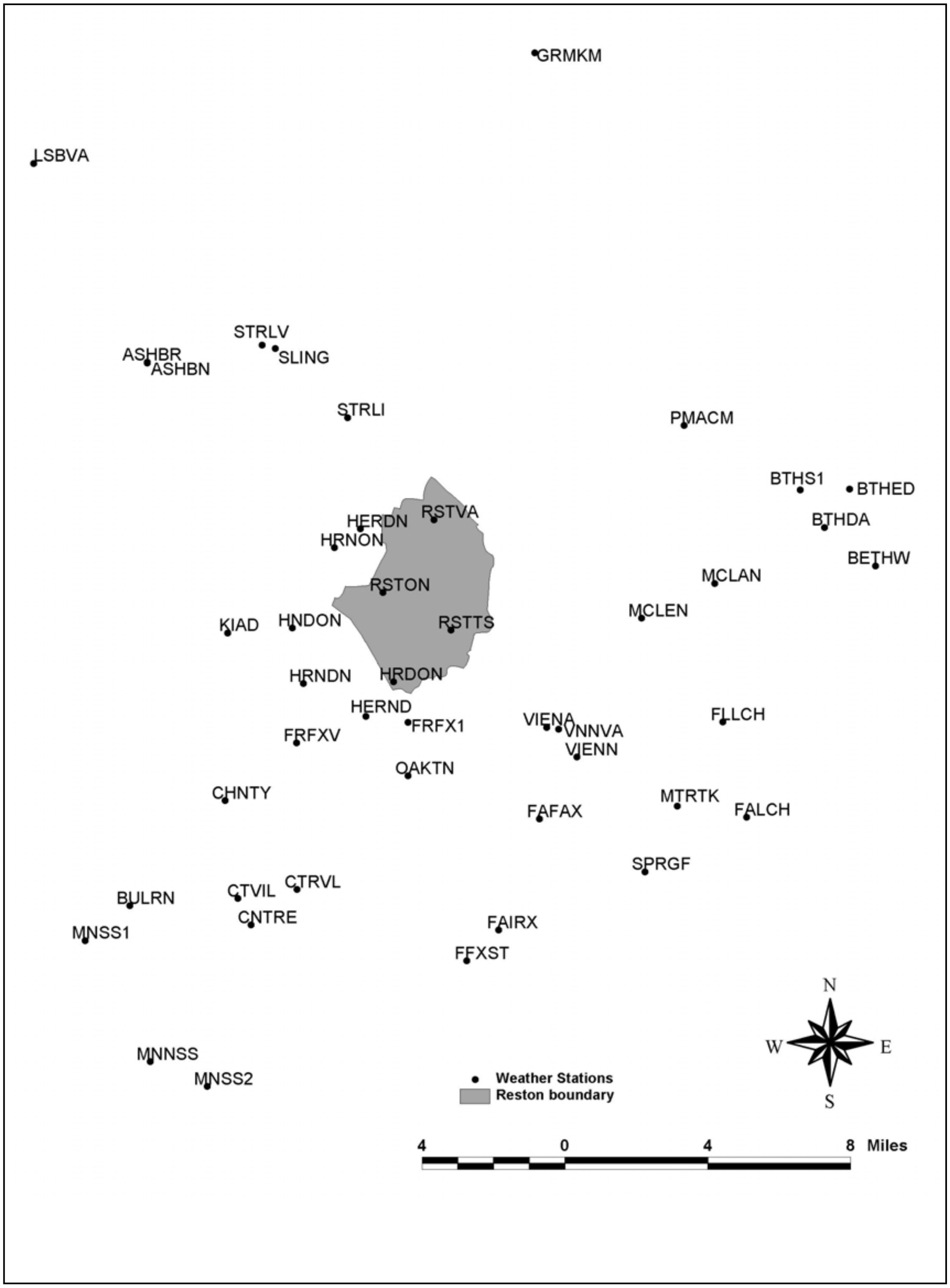


Figure 5-17 Weather station map

data sets gathered from weather stations installed at local schools and companies. Table 5-6 lists the names and location information (longitude, latitude, and elevation) of these weather stations. The collected climatic data covers weather conditions from April 2002 to March 2003. Each observation data set records hourly temperature, relative humidity, dew point, wind speed and direction, and rain. Although the data only presents weather conditions from a specific year, enough data was collected to successfully calibrate the analysis framework and computer program implementation.

Table 5-6 List of the names and location information of weather stations

ID	Name	Town	State	Latitude	Longitude	Elevation(ft)
ASHBN	Broad Run HS	Ashburn	VA	39.043889	77.487778	300
ASHBR	Farmwell Station MS	Ashburn	VA	39.044167	77.487778	300
BETHW	Westland MS	Bethesda	MD	38.958056	77.110556	508
BTHDA	Bannockburn ES	Bethesda	MD	38.973889	77.136667	508
BTHED	Landon School	Bethesda	MD	38.989167	77.123333	508
BTHS1	Holton-Arms School	Bethesda	MD	38.989167	77.149167	508
BULRN	Bull Run ES	Centreville	VA	38.824722	77.500000	447
CHNTY	Franklin MS	Chantilly	VA	38.866667	77.450000	330
CNTRE	Centreville ES	Centreville	VA	38.816389	77.437222	383
CTRVL	Centreville HS	Clifton	VA	38.830556	77.413056	447
CTVIL	Centre Ridge ES	Centreville	VA	38.827222	77.443889	322
FAFAX	Fairfax HS	Fairfax	VA	38.857778	77.286944	447
FAIRX	Robinson SS	Fairfax	VA	38.813056	77.308889	447
FALCH	Beech Tree ES	Falls Church	VA	38.857222	77.179444	447
FFXST	William Halley ES	Fairfax Station	VA	38.800833	77.325556	391
FLLCH	George Mason M/HS	Falls Church	VA	38.895833	77.191111	447
FRFX1	Westland Golf Inc	Fairfax	VA	38.897500	77.354444	40
FRFXV	Lees Corner ES	Fairfax	VA	38.889722	77.412500	447
GRMKM	Kingsview MS	Germantown	MD	39.167222	77.284167	508
HERDN	Herndon ES	Herndon	VA	38.975833	77.378056	447
HERND	Herndon HS	Herndon	VA	38.900000	77.376389	447
HNDON	Floris ES	Herndon	VA	38.936111	77.413889	365
HRDON	A. Scott Crossfield ES	Herndon	VA	38.913889	77.361667	447
HRNDN	Oak Hill ES	Herndon	VA	38.913611	77.408611	477
HRNON	Herndon MS	Herndon	VA	38.968333	77.391667	447
KIAD	Washington-Dulles International Airport	Washington	DC	38.934444	77.447500	95
LSBVA	Ball's Bluff ES	Leesburg	VA	39.125000	77.545833	313
MCLAN	Cooper MS	Mc Lean	VA	38.951944	77.194167	447
MCLEN	Spring Hill ES	Mc Lean	VA	38.938333	77.232500	447
MNNSS	RC Haydon ES	Manassas	VA	38.761667	77.490278	239
MNSS1	NOVA Manassas Campus	Manassas	VA	38.810833	77.523333	312

Table 5-6 (continued)

MNSS2	Osbourn High School	Manassas	VA	38.751389	77.460833	312
MTRTK	MitreTek Systems	Falls Church	VA	38.862222	77.215278	447
OAKTN	Waples Mill ES	Oakton	VA	38.875833	77.354722	416
PMACM	Bullis School	Potomac	MD	39.015833	77.208889	508
RSTON	U.S. Geological Survey	Reston	VA	38.950000	77.366667	410
RSTTS	Terraset ES	Reston	VA	38.934444	77.331667	447
RSTVA	Buzz Aldrin ES	Reston	VA	38.979167	77.339722	400
SLING	Potomac Falls HS	Sterling	VA	39.049167	77.421111	313
SPRGF	Ravensworth ES	Springfield	VA	38.835833	77.232500	447
STRLI	NOVA Loudoun Campus	Sterling	VA	39.020833	77.383889	313
STRLV	Lowes Island ES	Sterling	VA	39.050556	77.428056	313
VIENA	Flint Hill ES	Vienna	VA	38.894722	77.282500	345
VIENN	Marshall Road ES	Vienna	VA	38.882500	77.266944	447
VNNVA	James Madison HS	Vienna	VA	38.893889	77.276389	447

The data collection uses the WeatherBug Pro program, which was developed and provided by Automated Weather Source (AWS) Convergence Technologies, Inc. Figure 5-18 shows the WeatherBug Pro program interface. This program provides daily records of hourly climatic data sets. Then, seasonal and year-around data sets can be generated for each station by connecting daily records. Table 5-7 shows the typical data sets for two days in June 2002 from the Broad Run High School station.

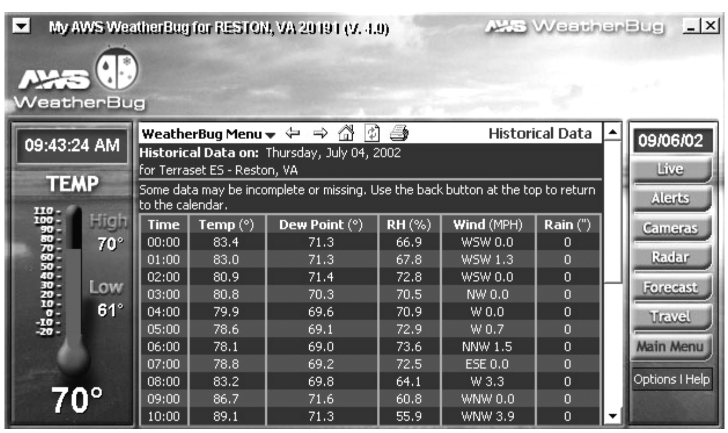


Figure 5-18 WeatherBug Interface

Table 5-7 Typical data sets for two days in June 2002 from the Broad Run High School station

Broad Run HS - Ashburn, VA
6/1/2002
Time Temp(°F) DewPoint(°F) RH(%) WindDir WindSpd(MPH) Rain (″)
00:00 69.9 65.7 86.4 NE 0.0 0
01:00 71.2 64.9 80.7 NE 0.0 0
02:00 69.9 64.4 82.6 NNE 3.7 0
03:00 69.9 64.4 82.6 N 0.0 0
04:00 71.4 64.6 79 NE 5.9 0
05:00 69.9 63.9 81.3 SE 0.0 0
06:00 67.4 64.2 89.7 NE 0.0 0
07:00 69.4 65.1 86.3 NE 0.0 0
08:00 74.0 65.2 74.2 NE 4.4 0
09:00 77.0 65.4 67.6 NNE 0.2 0
10:00 79.5 64.5 60.1 ENE 1.5 0
11:00 82.6 62.5 50.8 NNW 3.7 0
12:00 85.6 62.0 45.3 NNE 5.7 0
13:00 87.1 60.1 40.3 NNE 4.6 0
14:00 84.3 53.3 34.5 N 2.8 0
15:00 89.5 58.8 35.7 NE 3.7 0
16:00 89.9 58.4 34.8 NE 3.5 0
17:00 89.7 57.3 33.7 NE 4.4 0
18:00 88.1 54.9 32.5 ENE 5.3 0
19:00 87.1 56.1 35 NE 3.5 0
20:00 83.1 56.2 39.9 NNE 0.0 0
21:00 78.5 56.4 46.6 NE 0.0 0
22:00 74.5 56.7 53.9 NNE 0.0 0
23:00 71.6 57.7 61.5 NW 0.0 0
6/2/2002
Time Temp(°F) DewPoint(°F) RH(%) WindDir WindSpd(MPH) Rain (″)
00:00 70.9 56.7 60.7 NE 0.0 0
01:00 68.3 57.2 67.8 N 0.0 0
02:00 68.4 56.5 65.9 NNW 0.0 0
03:00 68.4 56.8 66.5 NNE 3.3 0
04:00 65.4 57.2 74.9 WNW 0.0 0
05:00 64.3 57.4 78.1 NW 0.0 0
06:00 66.4 59.9 79.7 N 5.5 0
07:00 66.4 60.0 80 W 0.0 0
08:00 78.0 62.7 59.5 NNE 7.0 0
09:00 79.5 64.6 60 NNE 4.2 0
10:00 82.0 65.5 58 W 5.9 0
11:00 81.5 64.2 56 ENE 5.3 0
12:00 83.1 58.8 43.8 E 12.1 0
13:00 82.6 48.8 30.9 NNE 6.1 0
14:00 82.6 45.6 27.4 NNE 6.8 0
15:00 82.6 45.2 27 NNE 6.6 0
16:00 82.9 44.4 25.9 ENE 11.2 0
17:00 82.5 43.5 25.3 NNE 12.3 0
18:00 79.5 40.6 24.9 NE 6.1 0
19:00 78.0 41.9 27.5 NE 0.9 0
20:00 72.9 42.5 33.4 NNE 0.0 0
21:00 70.9 42.8 36.2 ENE 4.4 0
22:00 69.4 43.3 38.9 NNE 3.9 0
23:00 66.4 43.5 43.4 SE 0.0 0

After collecting the observation data sets, we use the weather station in the Terraset Elementary School in Reston to plot the climatic data into two graphs: an annual temperature chart and an annual relative humidity chart (Figures 5-19 and 5-20). A scatter plot that puts

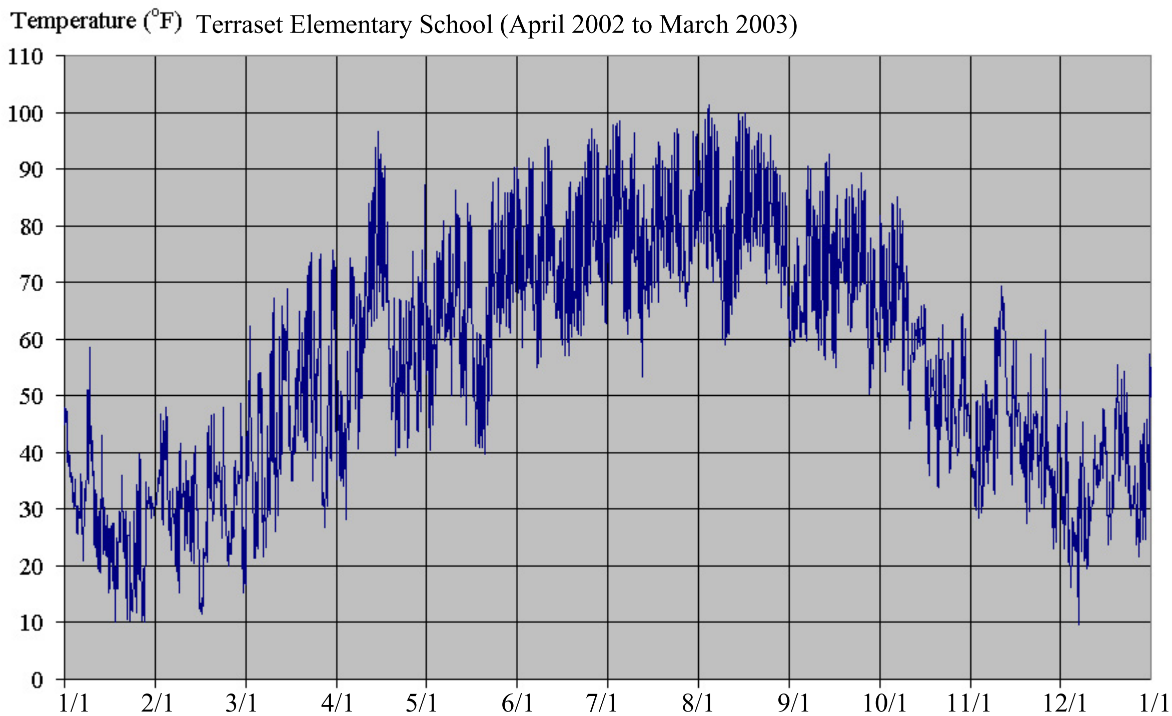


Figure 5-19 Annual temperature chart

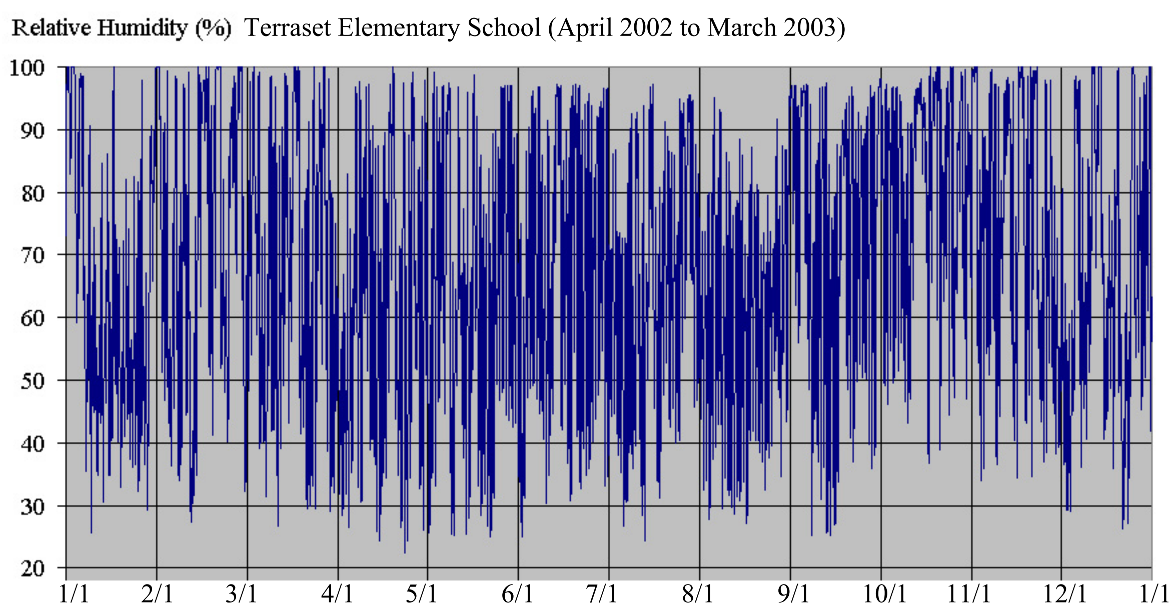
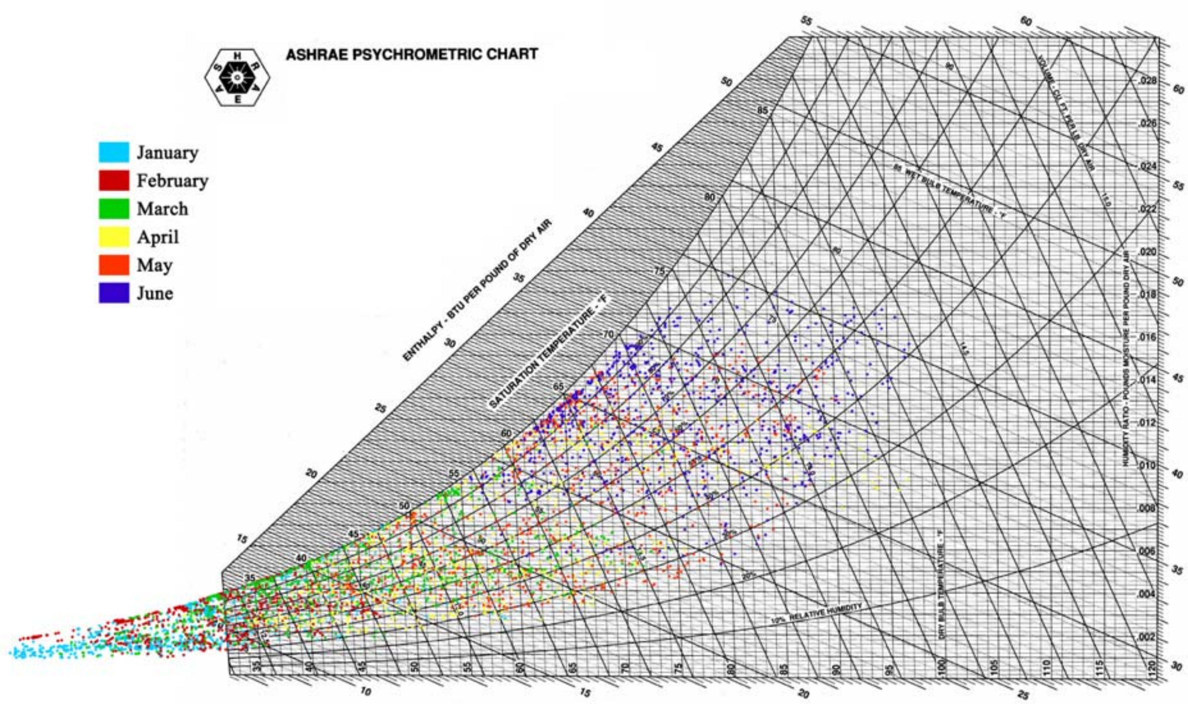
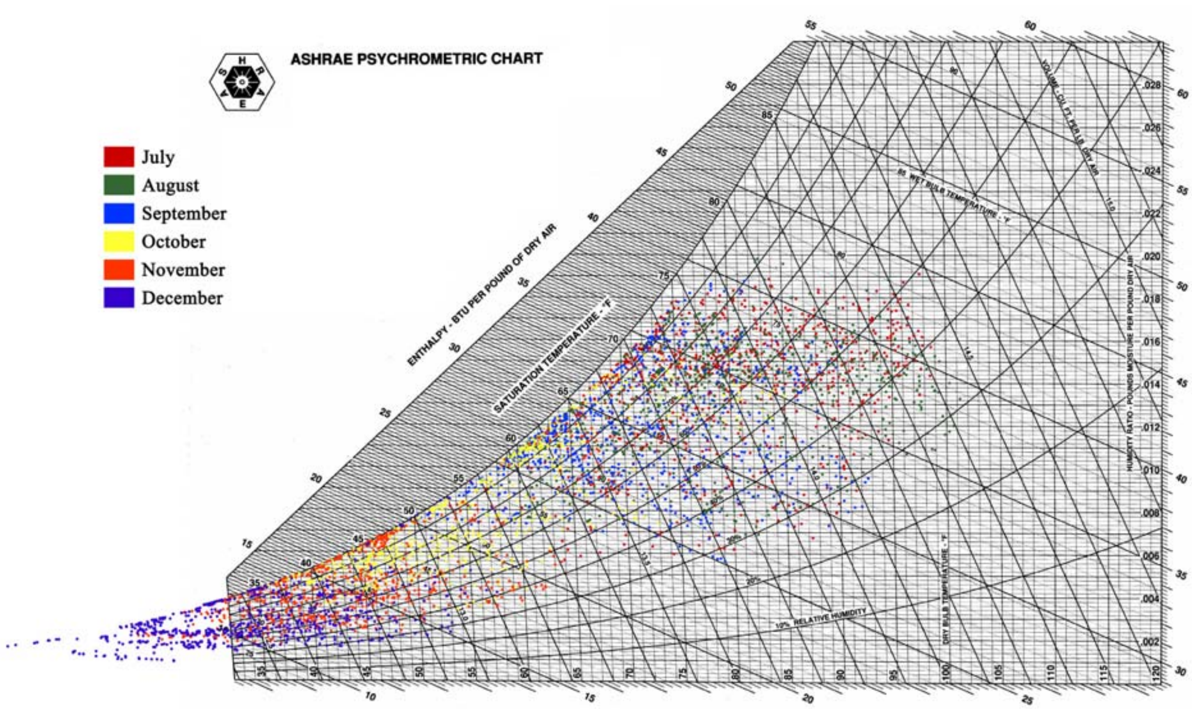


Figure 5-20 Annual relative humidity chart



Terraset Elementary School (April 2002 to March 2003)

Figure 5-21 Psychrometric chart (January to June)



Terraset Elementary School (April 2002 to March 2003)

Figure 5-22 Psychrometric chart (July to December) the hourly data into a psychrometric chart for each month shows the summarization of the climatic data for the whole year (Figures 5-21 and 5-22). Hourly solar radiation data sets from the Sterling station are used to complete the data sets (Table 5-8). These data sets present the specific climatic characteristic of Reston.

Table 5-8 Climatic data from the Sterling Station

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Radiation Average (39^o) (kWh/m2/day)	**3.5**	**4.2**	**4.8**	**5.3**	**5.5**	**5.7**	**5.6**	**5.5**	**5.1**	**4.6**	**3.6**	**3.1**	**4.7**
Radiation Min.	2.5	3.1	3.9	4.3	4.9	4.9	4.6	4.8	4.4	3.6	2.4	2.5	4.3
Radiation Max.	4.3	5.2	5.7	6.6	6.1	6.3	6.2	6	6	5.6	4.5	3.7	5.1
Temperature (^{o}F)	30.6	33.6	43.2	52.7	62.2	71.1	75.6	74.1	67.1	55.0	45.3	35.4	53.8
Temperature Min.	21.0	23.4	31.8	40.3	50.0	59.2	64.0	62.8	55.4	42.4	34.2	25.9	42.4
Temperature Max.	40.1	43.9	54.7	65.1	74.3	82.8	87.1	85.5	79.0	67.6	56.7	45.0	65.1
Wind Speed (mph)	8.3	8.5	9.2	8.7	7.6	6.7	6.3	5.8	6.0	6.7	7.6	7.8	7.6
Relative Humidity (%)	68	66	63	62	70	72	73	74	75	73	70	69	70

In addition, hourly data sets are generated through data queries[4] in Microsoft Access. Each data set provides hourly climatic information from all stations, along with an indication of date and time (Table 5-9).

Table 5-9 Result tables cover information from all stations

ID	Date	Time	Temperature (°F)	Dew Point (°F)	Relative Humidity (%)	Wind direction	Wind speed (mph)	Rain (″)
ASHBN	6/1/2002	12:00	85.6	62	45.3	NNE	5.7	0
BETHW	6/1/2002	12:00	83.9	64.9	52.9	W	0	0
BTHDA	6/1/2002	12:00	88	66.8	49.6	W	3.1	0
BTHED	6/1/2002	12:00	83.2	62.9	50.4	NW	3.9	0
BULRN	6/1/2002	12:00	84.9	59.7	42.6	W	6.6	0
CHNTY	6/1/2002	12:00	86.9	65.1	48.5	NW	5.5	0
CNTRE	6/1/2002	12:00	87.7	58.3	37	WNW	0	0
CTVIL	6/1/2002	12:00	86	62.1	44.9	SW	6.1	0
FAIRX	6/1/2002	12:00	87.8	55.1	32.9	W	0	0
FALCH	6/1/2002	12:00	87.2	62.6	44.1	WSW	1.8	0
FLLCH	6/1/2002	12:00	85.6	60.6	43	E	6.6	0
FRFXV	6/1/2002	12:00	84.6	58.5	41.2	SSE	5.5	0
GRMKM	6/1/2002	12:00	81.6	62.4	52.3	NW	6.1	0
HERDN	6/1/2002	12:00	88.8	62.8	42.1	WNW	3.5	0
HERND	6/1/2002	12:00	80.7	61.6	52.3	WSW	0	0
HRDON	6/1/2002	12:00	88.1	65.8	48	SSE	3.1	0
HRNDN	6/1/2002	12:00	84.1	61.5	46.7	SSW	6.1	0

[4] The code of data queries is listed in the Appendix C.

Table 5-9 (continued)

HRNON	6/1/2002	12:00	85.7	59.6	41.4	NW	3.1	0
KIAD	6/1/2002	12:00	84.2	60.3	44.7	WNW	8.1	0
LSBVA	6/1/2002	12:00	87.4	60.7	40.8	W	6.1	0
MCLAN	6/1/2002	12:00	88.3	65.2	46.6	N	0	0
MCLEN	6/1/2002	12:00	85.4	57.9	39.4	WNW	5.5	0
MNNSS	6/1/2002	12:00	87.6	61.6	41.9	NNW	2	0
MNSS1	6/1/2002	12:00	88.3	59.9	38.6	W	5.9	0
MTRTK	6/1/2002	12:00	87.3	61.9	42.8	NNE	3.9	0
OAKTN	6/1/2002	12:00	85.2	61.8	45.6	WNW	0.7	0
PMACM	6/1/2002	12:00	85	67.3	55.5	SSW	0	0
RSTON	6/1/2002	12:00	87	64.6	47.4	E	4.8	0
RSTTS	6/1/2002	12:00	86.3	65.6	50.3	N	0	0
RSTVA	6/1/2002	12:00	87.1	64.3	46.8	WSW	3.7	0
SLING	6/1/2002	12:00	87.6	62.9	43.8	W	4.4	0
STRLI	6/1/2002	12:00	83.4	59.9	45.1	S	1.5	0
VIENA	6/1/2002	12:00	88	66.5	49.1	SSE	2.2	0
VIENN	6/1/2002	12:00	88.5	65.3	46.4	NW	9.2	0

5.3.2 Map Generation

Figure 4-17 shows that this research uses ArcView GIS to generate both descriptive maps (hourly temperature, relative humidity, wind direction, and wind speed maps) and result maps (comfort zone maps, wind direction maps, and wind speed maps).

There are three steps used to generate the descriptive maps. First, to generate an hourly climatic map, an hourly climatic data set (Table 5-9) is combined with the location information of each station from the station list[5] (Table 5-6). Each point in this map represents a weather station and stores the climatic information of a particular hour (Figure 5-17).

The second step is to interpolate the point data set into a grid map. In this research, the grid size is 50 ft. by 50 ft. It is fine enough to analyze lot sites for single-family houses in Reston, which range from 5000 sq.ft. to 87000 sq.ft. The interpolation technique provides the climatic condition in each piece of land in Reston by using measurements from the nearby weather stations. Three interpolation processes are needed for each hour in order to generate hourly descriptive grid maps, including hourly temperature, relative humidity, and

[5] Sample script used for combining station data and climatic data is listed in Appendix D.

wind speed maps (Figures 5-23, 5-24, and 5-25). The wind direction maps continue to be the point data maps.

The third step is to apply various classifications to the descriptive maps to obtain result maps. Depending on the different methods used in the analysis, the corresponding criteria will be applied to the descriptive maps. The overall results can be obtained by repeating the first and second steps for each hourly data set and then applying different criteria to the descriptive maps.

The climatic analysis for CE is bases on the thermal comfort zone criteria set by ASHRAE. Section 4.3 has already described these criteria. Figures 4-4 and 4-5 show the flowchart of generating the result from descriptive grid maps, including hourly temperature and relative humidity. Figure 5-26 is the result map for summer comfort zone analysis, and Figure 5-27 is the overall climatic analysis map for CE.

According to feng shui, a site should be protected from the winter wind and welcome a gentle summer breeze. The desired wind speed is less than five mph for less than 20% of the time in the winter ("w_windy" map) and less than eight mph in summer ("windy" map). The "wind_nw" map also identifies areas with northwest winter wind in the wind direction map. In addition, hilltops and areas facing the prevailing winter wind are also possible windy areas (Section 4.3). Both "peak" and "asp_nw" maps are derived from the topographic analyses. Therefore, the wind analysis uses five maps: "wind_nw," "w_windy," "peak," "asp_nw," and "windy" maps (Figure 4-6). The colored part in the result "fs_climate" map shows areas that are not windy (Figure 5-28).

5.4 Hydrology Data

The basic hydrology data sets are floodplain, wetland, and river maps, which are available for Fairfax County. For contemporary environmental design methods, hydrologic analyses use the wetland and floodplain maps (Figure 4-8). The wetland map shows that no area in Reston is located in the wetland. The floodplain map shows potential flood areas. Therefore, the resulting "ce_hydro" map comes from the floodplain analysis and indicates the areas that are not in potential flood zones and suitable for residential development (Figure 5-29).

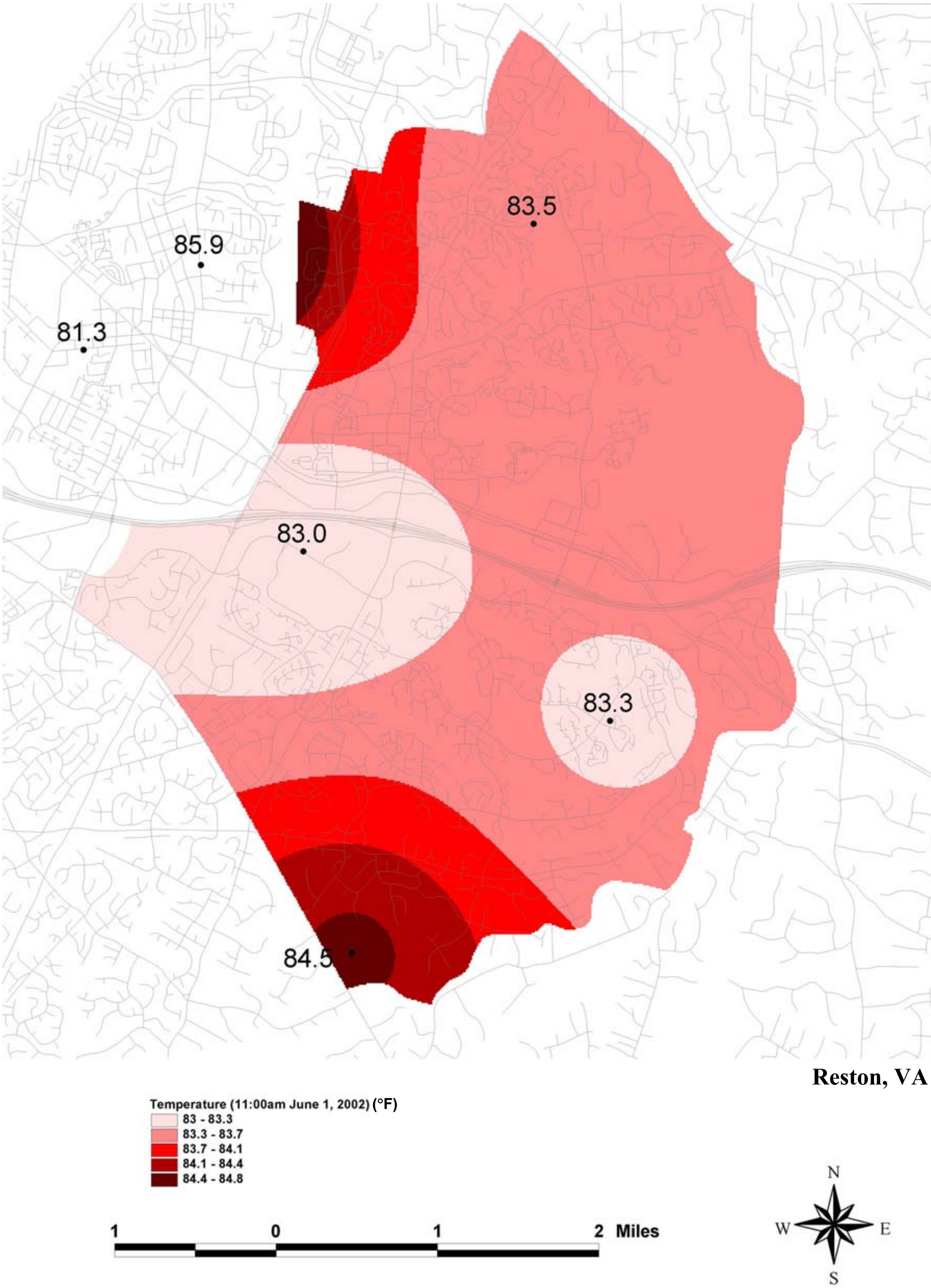


Figure 5-23 Hourly temperature map

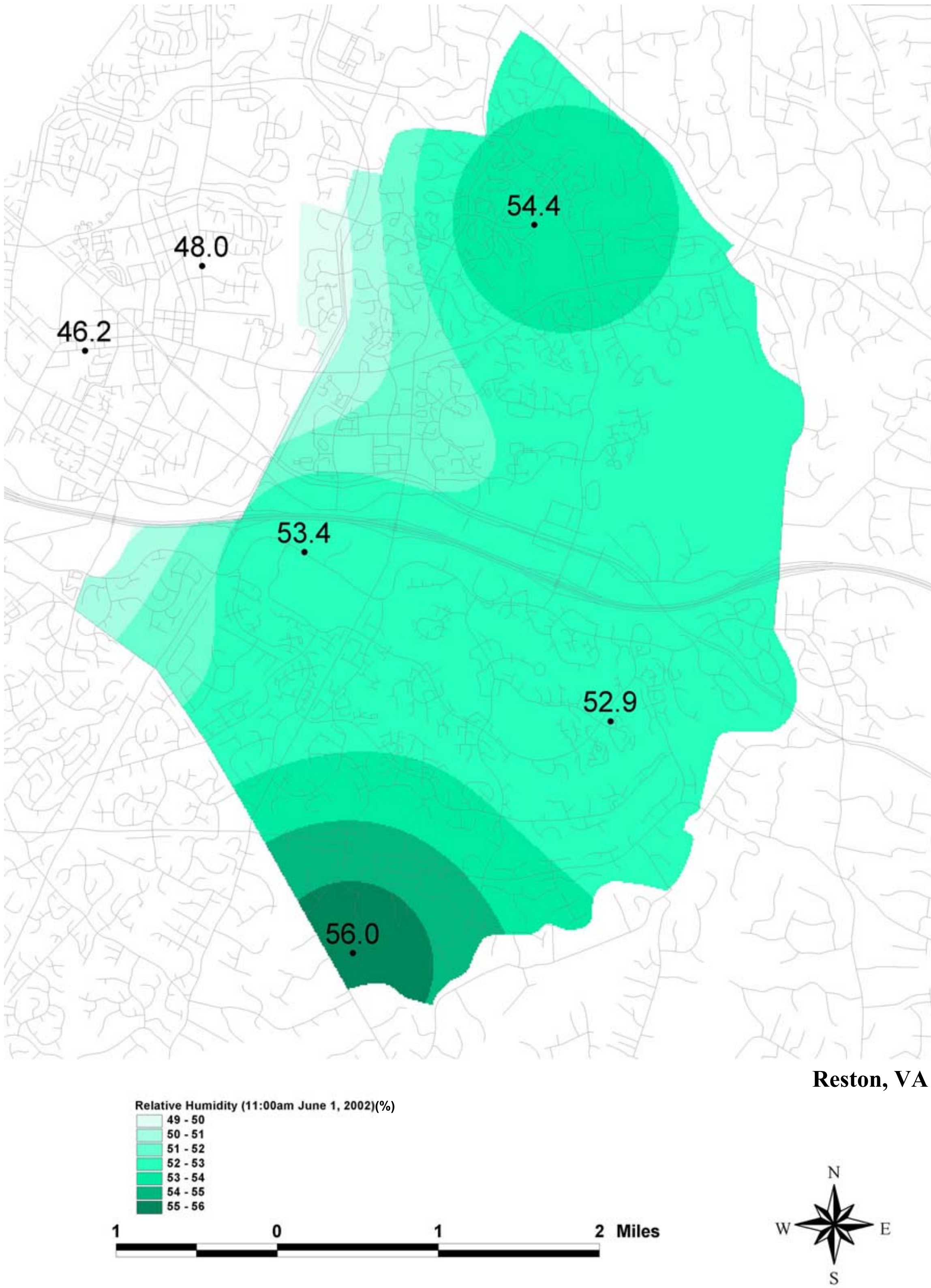


Figure 5-24 Hourly humidity map

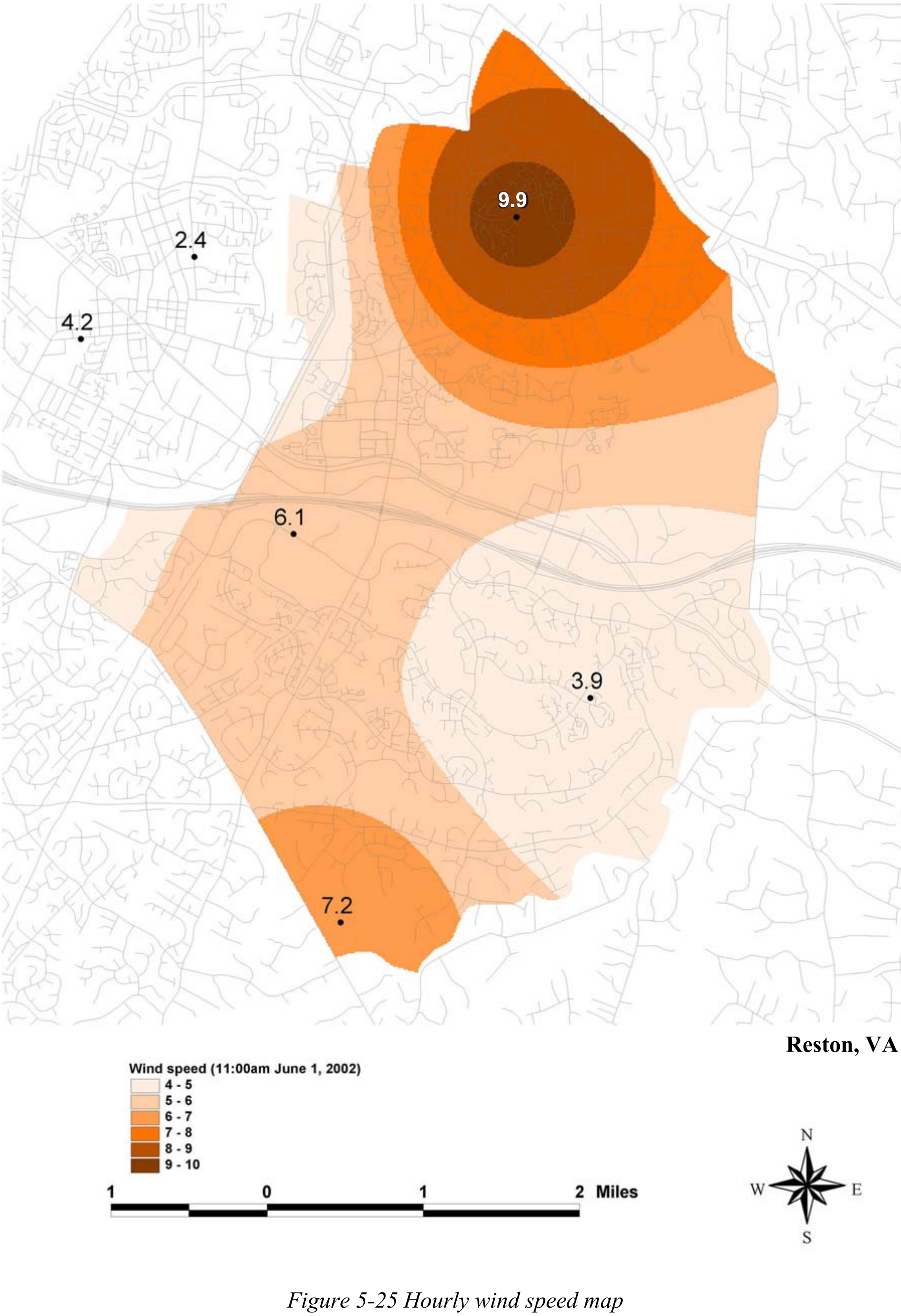


Figure 5-25 Hourly wind speed map

Figure 5-26 Result comfort zone map (summer)

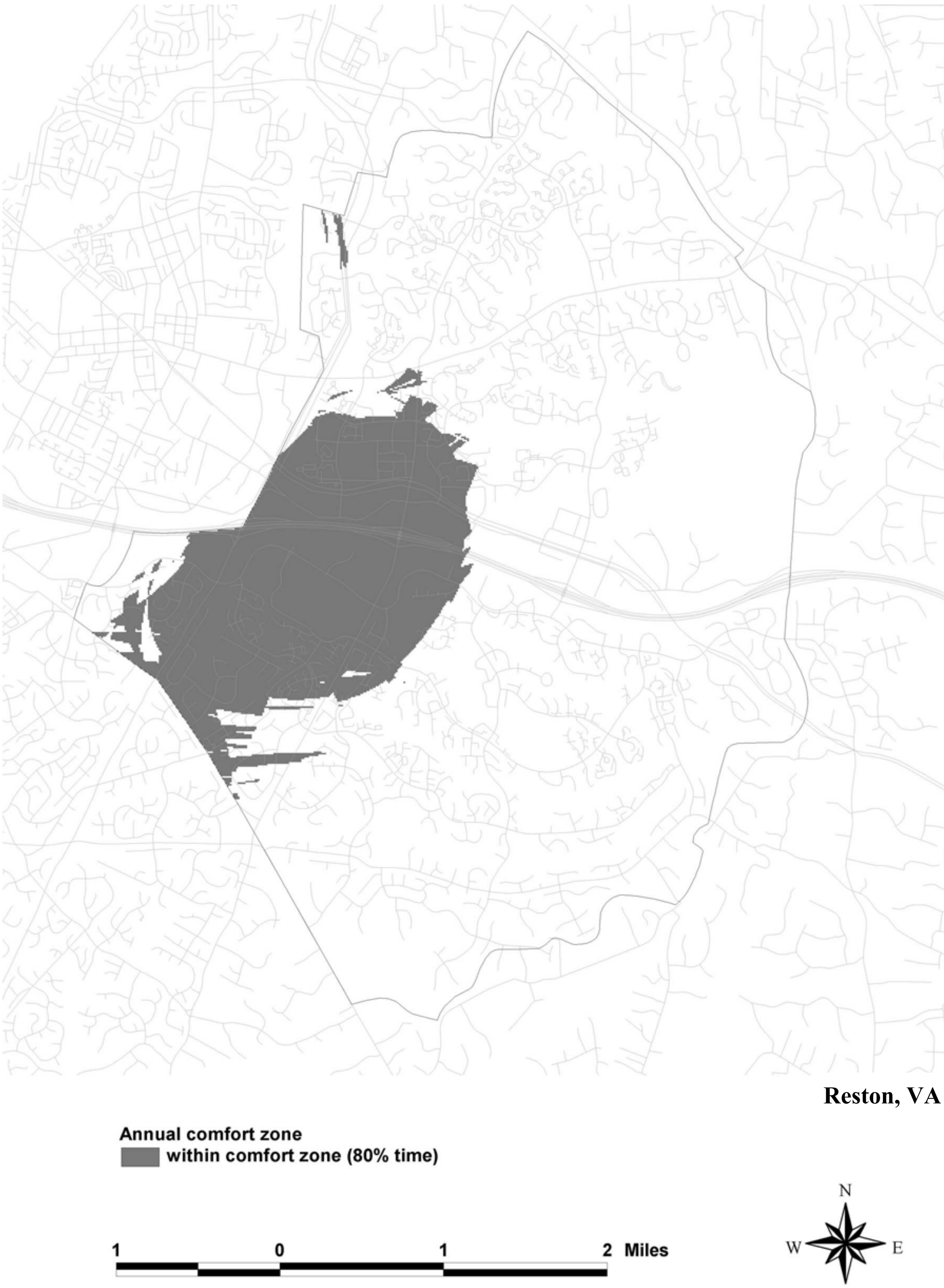


Figure 5-27 "ce_climate" – result comfort zone map (annual)

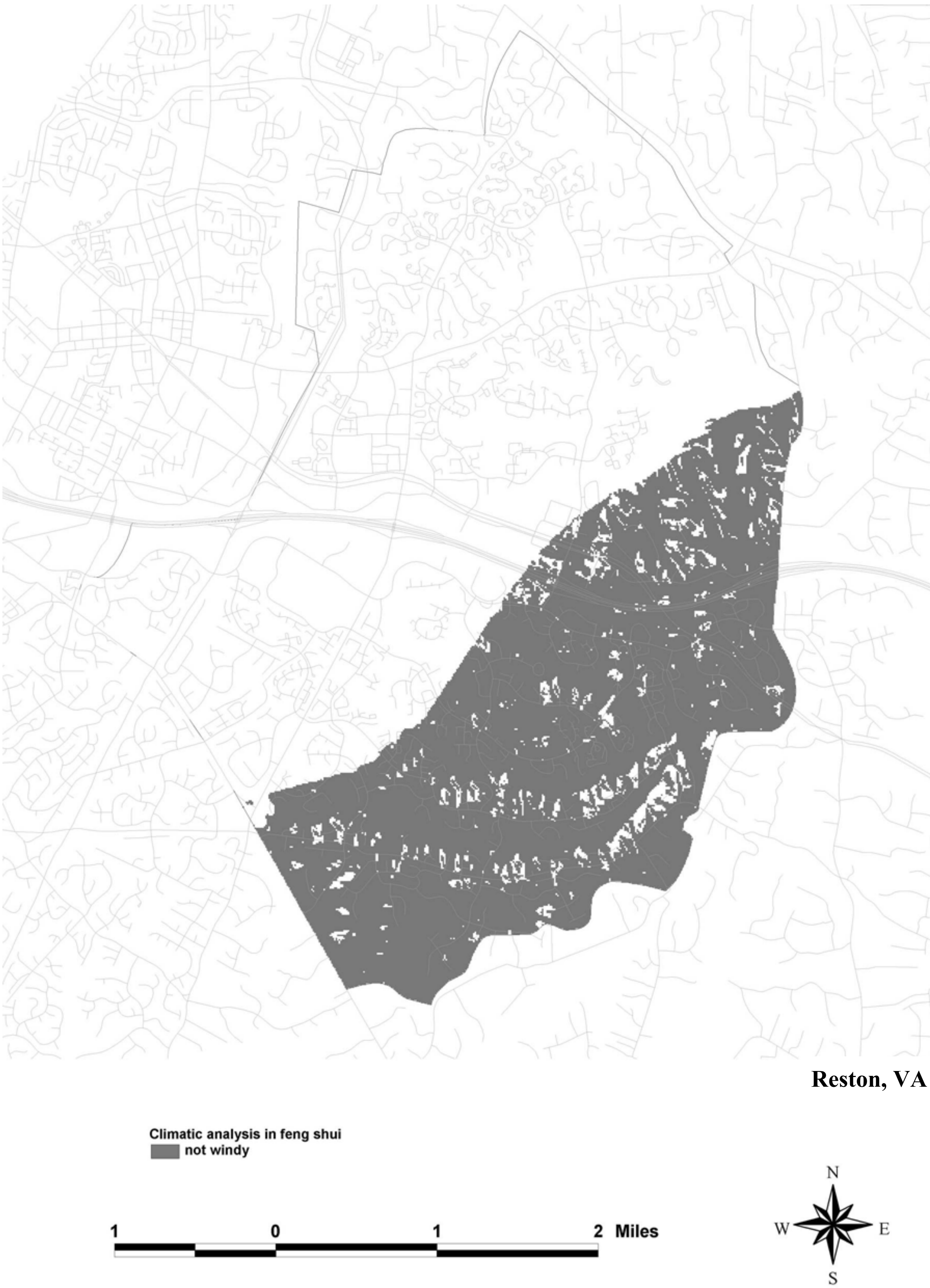


Figure 5-28 "fs_climate" map

Feng shui uses the hydrological data sets and the derived topographic data sets. According to feng shui principles, a favorable site might feature a body of water forming a lake or joining a stream. However, while it should be near a body of water, it should also avoid potential floods. Consequently, this study assumes that a distance between 300 ft. and 1500 ft. from a body of water is desirable. By using different buffer zones, we can generate a resulting "river" map. In addition, the flood analysis map also comes from several derived maps. Feng shui considers lower, flat areas near rivers as potential flood areas. Thus, the results from the topographic analysis maps ("lowest" and "slope4" maps) and the hydrological maps (the wetland, floodplain, and "river" maps) are used to generate the resulting flood map. Like the topographic analysis maps, the colored cells in each map are considered favorable, while the uncolored ones are unfavorable. Figure 4-9 shows the flowchart of the hydrological analysis using feng shui. The resulting "fs_hydro" map comes from five sub-composition maps, including the wetland, flood, river, "slope4," and "lowest" maps (Figure 5-30).

5.5 Other Maps

The soil map and the tree coverage map are among other data sets analyzed in GIS. Both of these are available for Fairfax County, and the analyses on both original data sets are straightforward.

Geological Analysis

The geological analysis considers soil ratings and erosion potential (Figure 4-7). Based on soil ratings, the soil analysis differentiates between soil types that it considers suitable for development and those that it considers unsuitable according to regulations and building codes. There are three soil rating classes in Fairfax County, Virginia (Problem Soils Ordinance of Fairfax County, Virginia). According to the ordinance, no construction shall occur on land containing "Class A" soils, such as Cretaceous-age Potomac Group clays and other shrinking and swelling clays. The ordinance also suggests that wetness and drainage problems of "Class B" soils can be addressed with appropriate geotechnical notes and drawings. In addition, no special foundation treatment is needed for "Class C" soils. Based

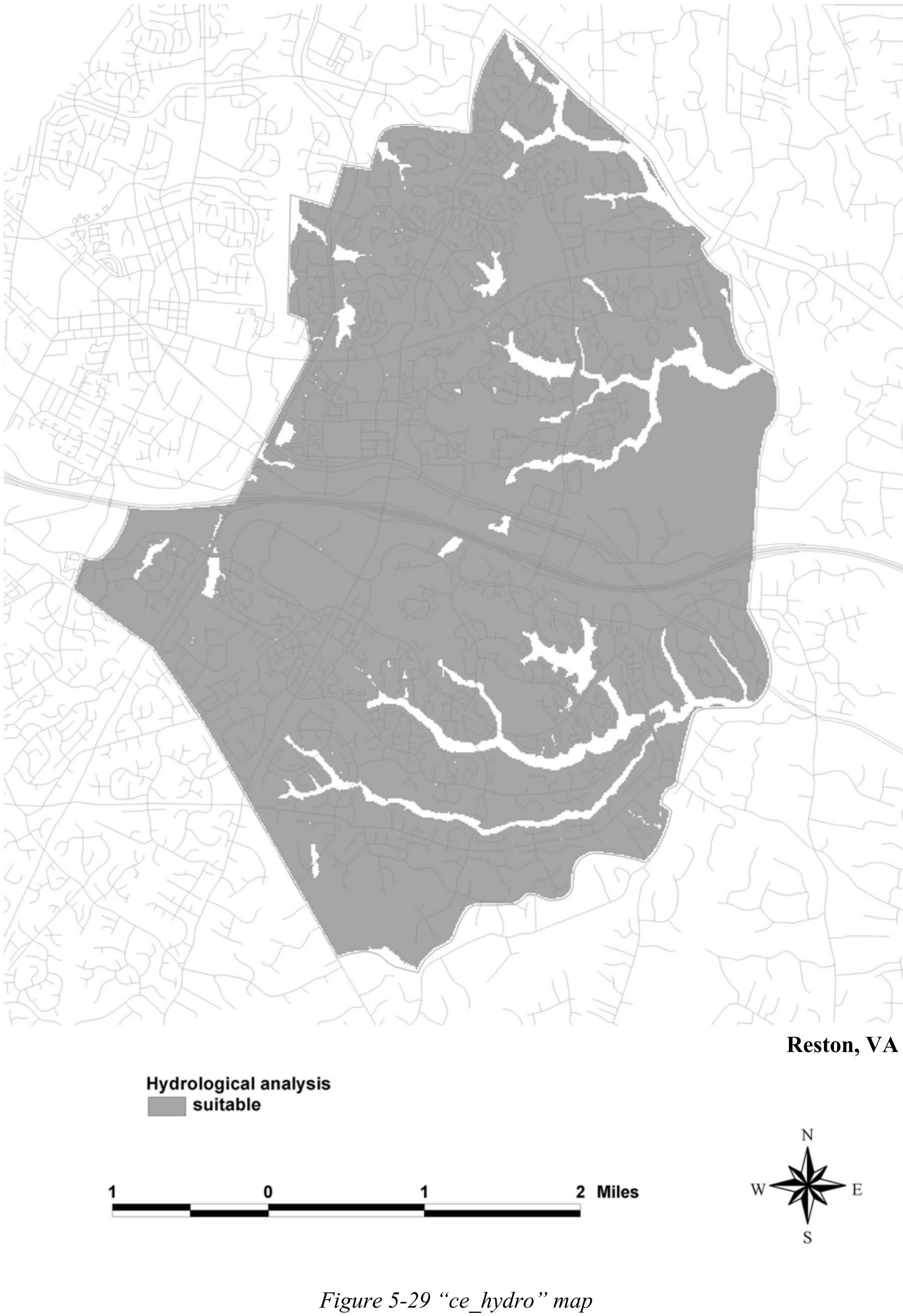


Figure 5-29 "ce_hydro" map

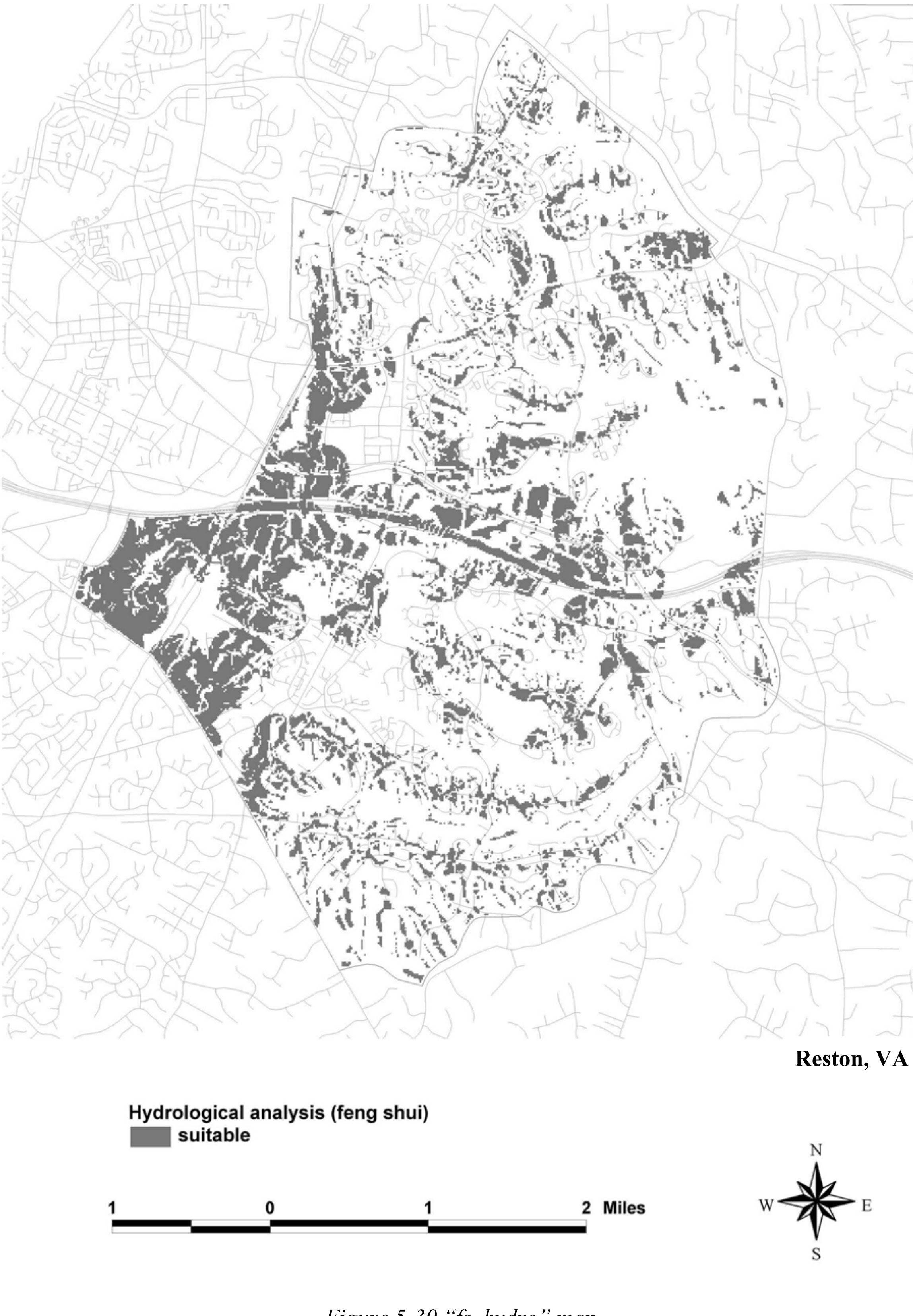


Figure 5-30 "fs_hydro" map

on the ordinance and the BOCA National Building Code (1999), the soil analysis in this study considers the land with "Class A" soils is unsuitable for development, and the land with other soil types is suitable.

Additionally, the contemporary environmental design approaches are highly concerned with erosion that land developments should avoid potential erosion areas; while feng shui favors gentle slopes. Therefore, contemporary principles use the soil-type map and the erosion map for their soil analysis (Figure 5-34). According to the ordinance, there are five potential erosion symbols and five slope classes on the soil maps (Table 5-10). Erosion symbols "+," "0," and "1" indicate low erosion potential. Erosion symbols "2" and "3" represent moderate and severe erosion potential. A and B slopes are less than 7%; and C, D, and E slopes are greater than 7%. The ordinance also notes that soils are moderately erodible on B slopes and highly erodible on C slopes or greater. Therefore, this study considers areas with low-potential erodible soils, indicated by erosion symbols "+," "0," and "1", and moderate-potential erodible soils with less than 7% slopes, indicated by erosion symbol "2" with A and B slopes, are suitable for development. Figure 4-7 shows the geologic analysis flowchart. Figure 5-31 is the result map.

Table 5-10 Erosion and Slope symbols in Reston soil map[6]

Potential Erosion Symbols	Slope Classes
+ - Soil Accumulation (Low)	A 0-2 %
0 - No Erosion (Low)	B 2-7 %
1 - Slight Erosion (Low)	C 7-14 %
2 - Moderate Erosion (Mod)	D 14-25 %
3 - Severe Erosion (High)	E > 25 %

Vegetation Analysis

Both feng shui and contemporary environmental principles highlight vegetation as an important factor for a desirable site. However, the available tree coverage information only distinguishes coniferous or deciduous species. In order to preserve the existing native plants, the vegetation analysis in this research considers areas covered by the deciduous are not suitable to development (Figure 4-12). It is easy to identify favorable areas in the original tree coverage map by highlighting the colored areas (Figure 5-32).

[6] From http://www.co.fairfax.va.us/gov/dpwes/environmental/soilrating.htm.

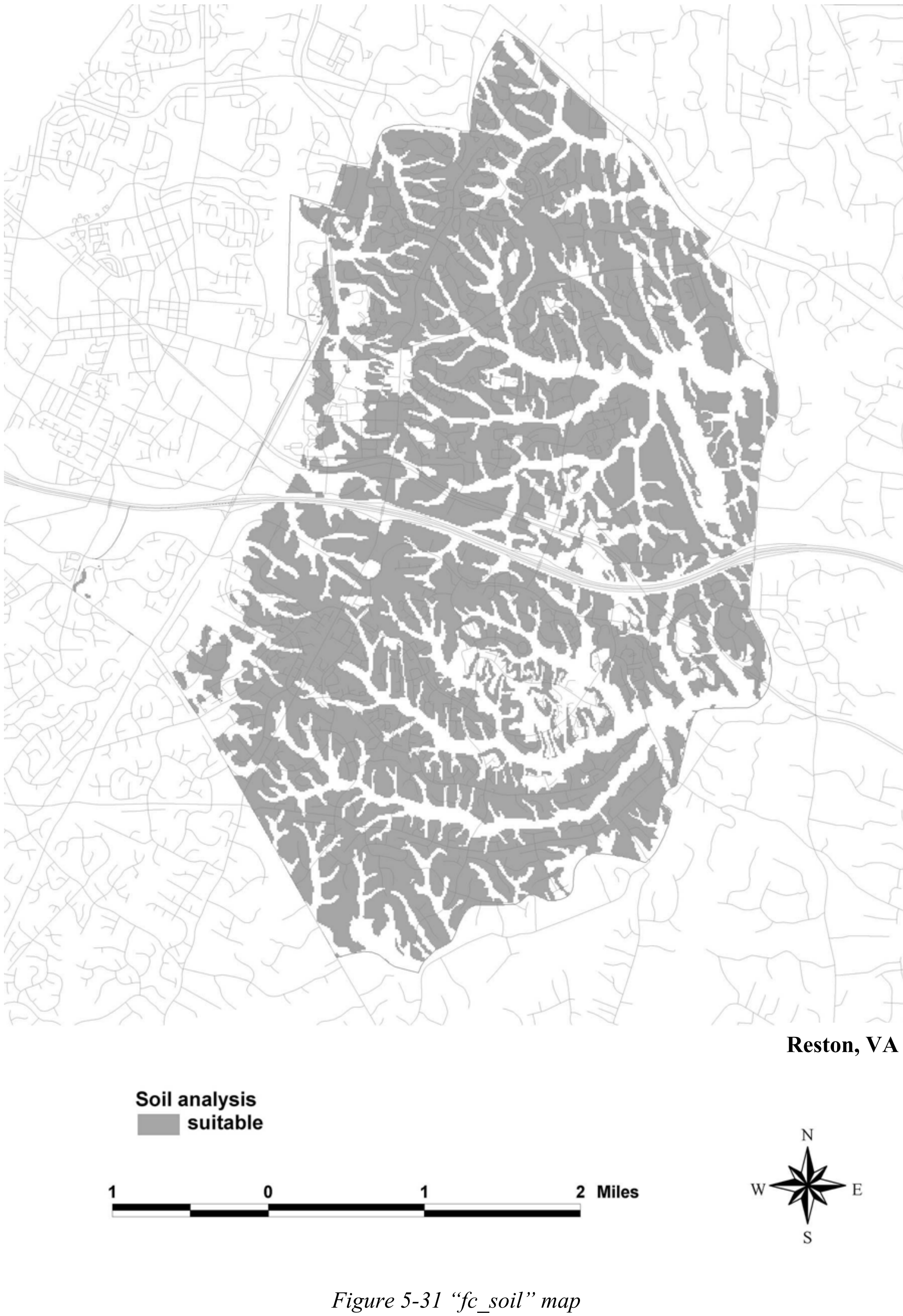


Figure 5-31 "fc_soil" map

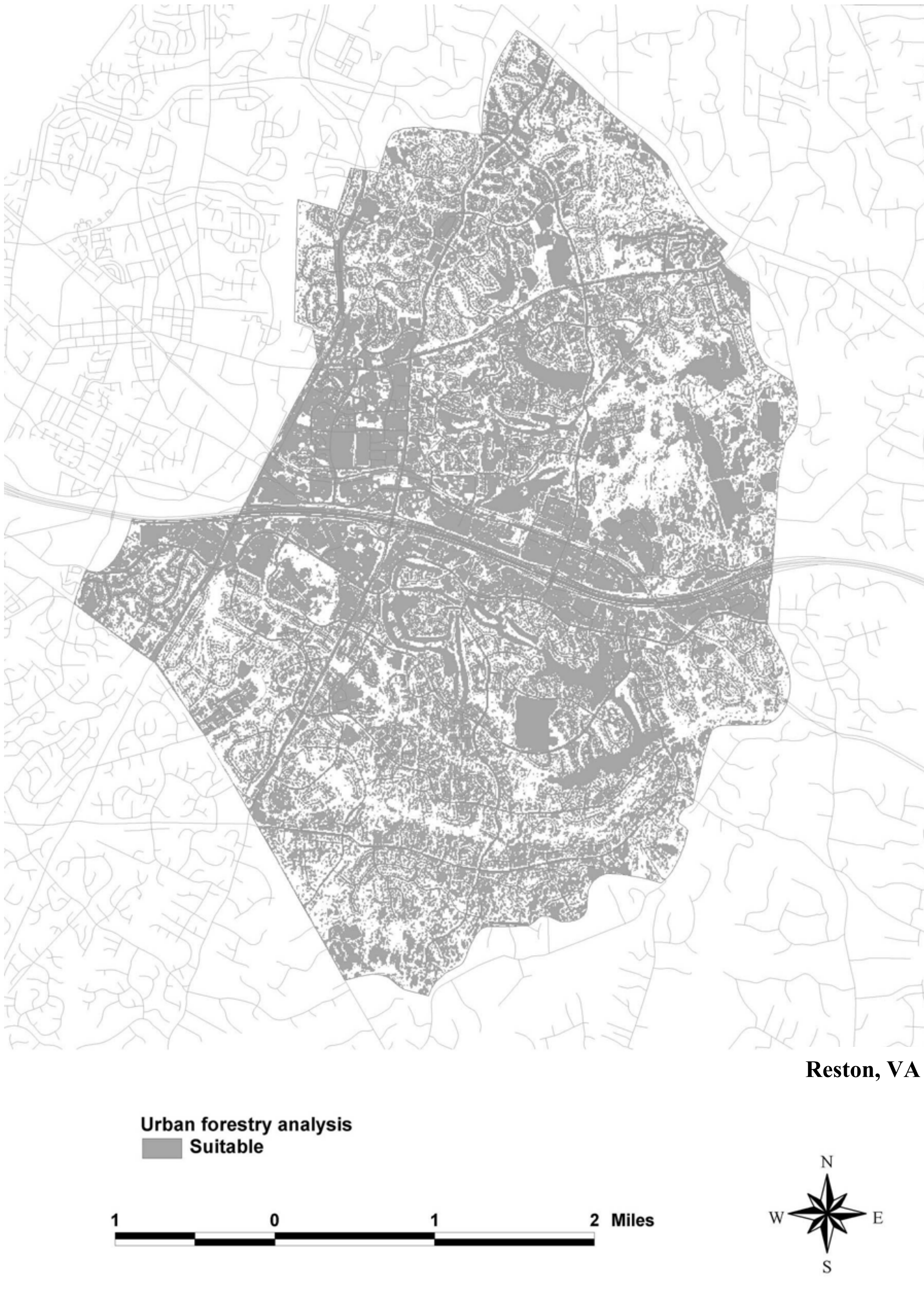


Figure 5-32 "fc_veg" map

Other Maps

This research also uses a set of maps, including maps of buildings, bodies of water, zoning, public facilities, historic sites, historic areas, schools, and parcel (Appendix E). All maps are available from Fairfax County. The maps used in the interviews with professionals are portions of larger maps, which cover all of Fairfax County. The set of maps also includes an aerial photo derived from nine Digital Orthophoto Quarter Quad (DOQQ)[7] maps.

5.6 Result Maps

This study contains three overall result maps that are generated from feng shui, contemporary environmental design methods, and an integrated approach that incorporates both methods. Each overall map comes from five sub-composition maps: climate, topography, hydrology, soil, and vegetation maps. The above sections describe the procedures for creating the sub-composition maps for feng shui and contemporary analyses. Figure 5-33 summarizes these procedures through two comprehensive flowcharts. Figures 5-34 and 5-35 show the overall results from feng shui and contemporary principles.

Each sub-composition map for the integrated approach comes from the corresponding maps in feng shui and contemporary environmental design methods. For example, the "fc_topo" map identifies the areas that are colored in both topographic maps from feng shui ("fs_topo" map) and from contemporary principles ("ce_topo" map). These areas are favorable in terms of the topographic analyses. Figure 5-36 shows a flowchart of how all five sub-composition maps are generated. Appendix A includes each process for generating these sub-composition maps. Figure 5-37 is the overall integration map.

In summary, this chapter discusses the different data collection and analysis methods for each criterion in this study. It presents a flowchart for each procedure. These flowcharts not only show the data types and the analysis methods, but also clarify the decision-making processes, which may be embedded within SiteOne. This chapter also presents the analysis results from single categories, as well as the overall outcome.

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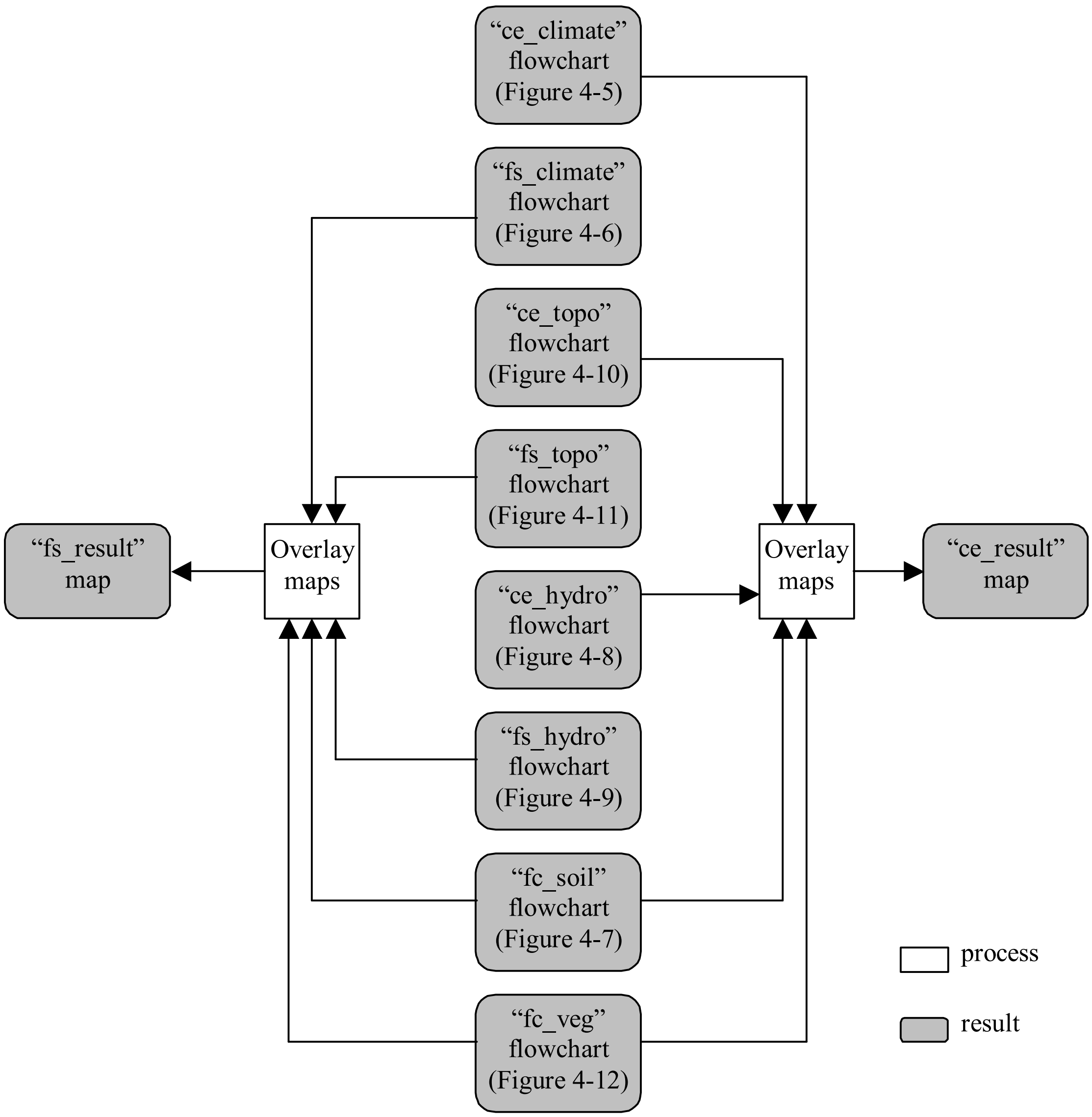
[7] DOQQs are produced by USGS and Virginia Economic Development Partnership (VEDP). They are scanned aerial photographs corrected for geometric distortion. For more information of DOQQs, please check VEDP's website at http://gis.vedp.org.



Note: Figure numbers indicate the flowcharts to generate the result maps. Appendix A includes all flowcharts.

Figure 5-33 Flowchart for feng shui and contemporary principles

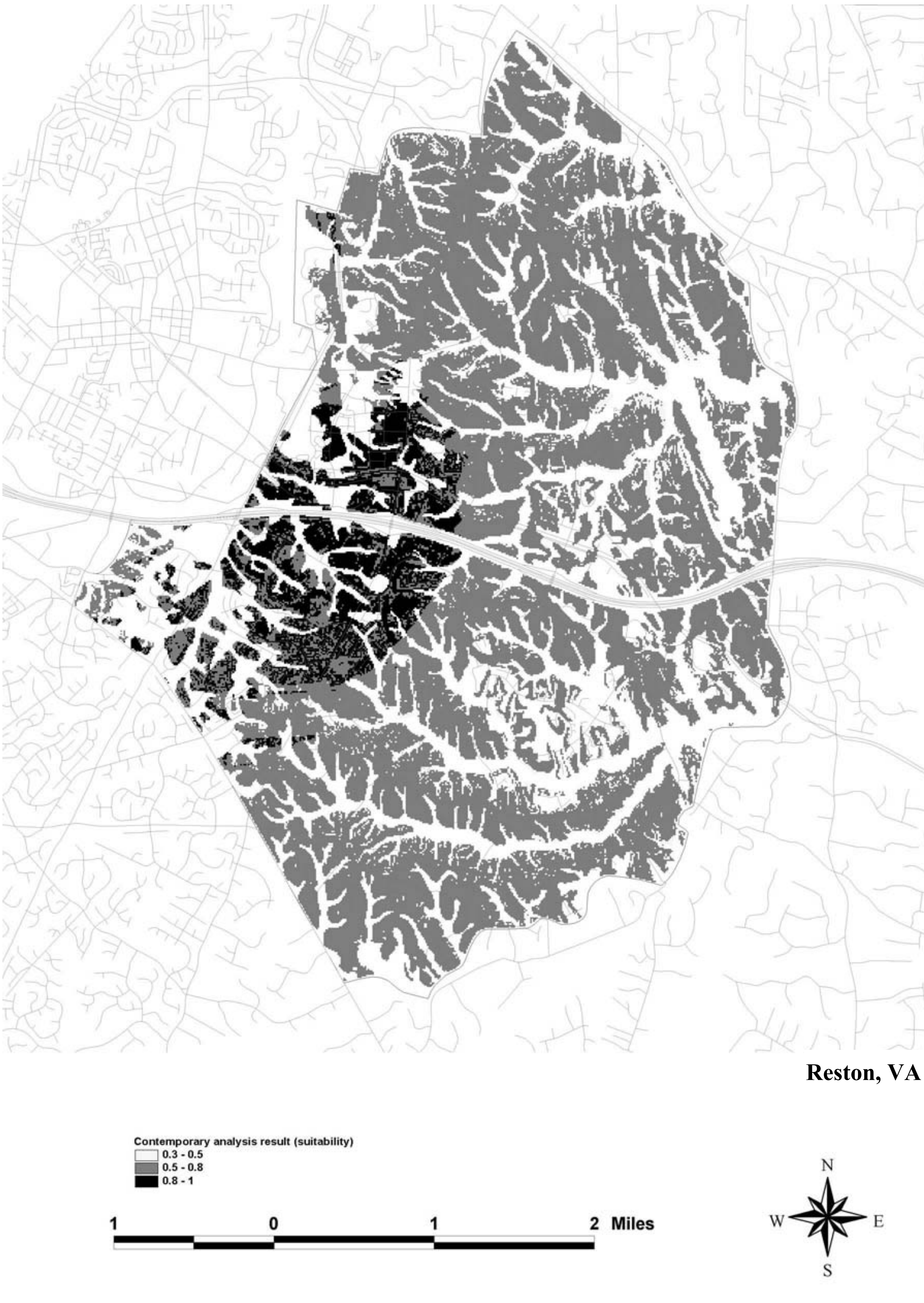


Figure 5-34 "ce_result" map

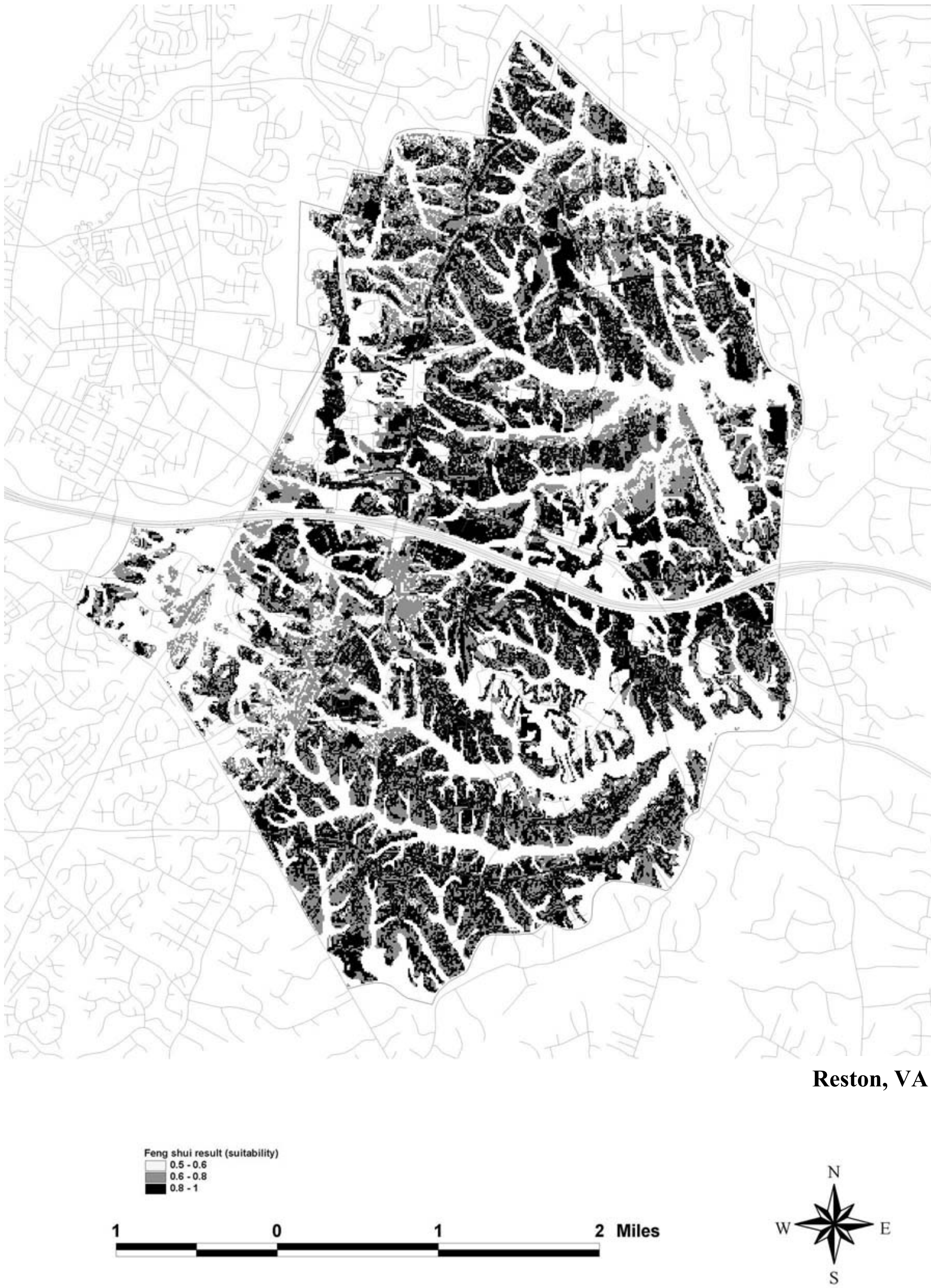


Figure 5-35 "fs_result" map

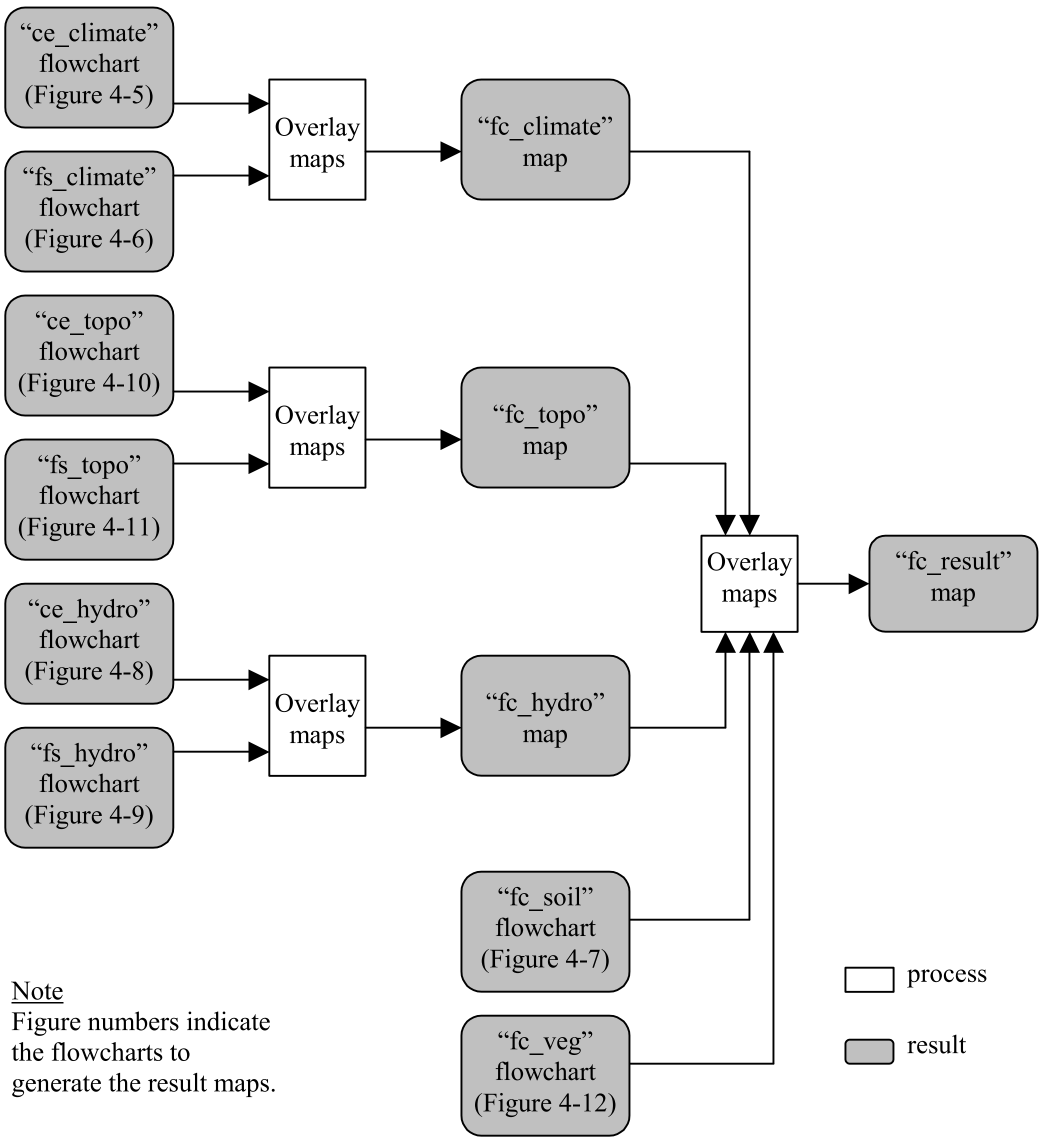


Figure 5-36 Flowchart for the integrated method

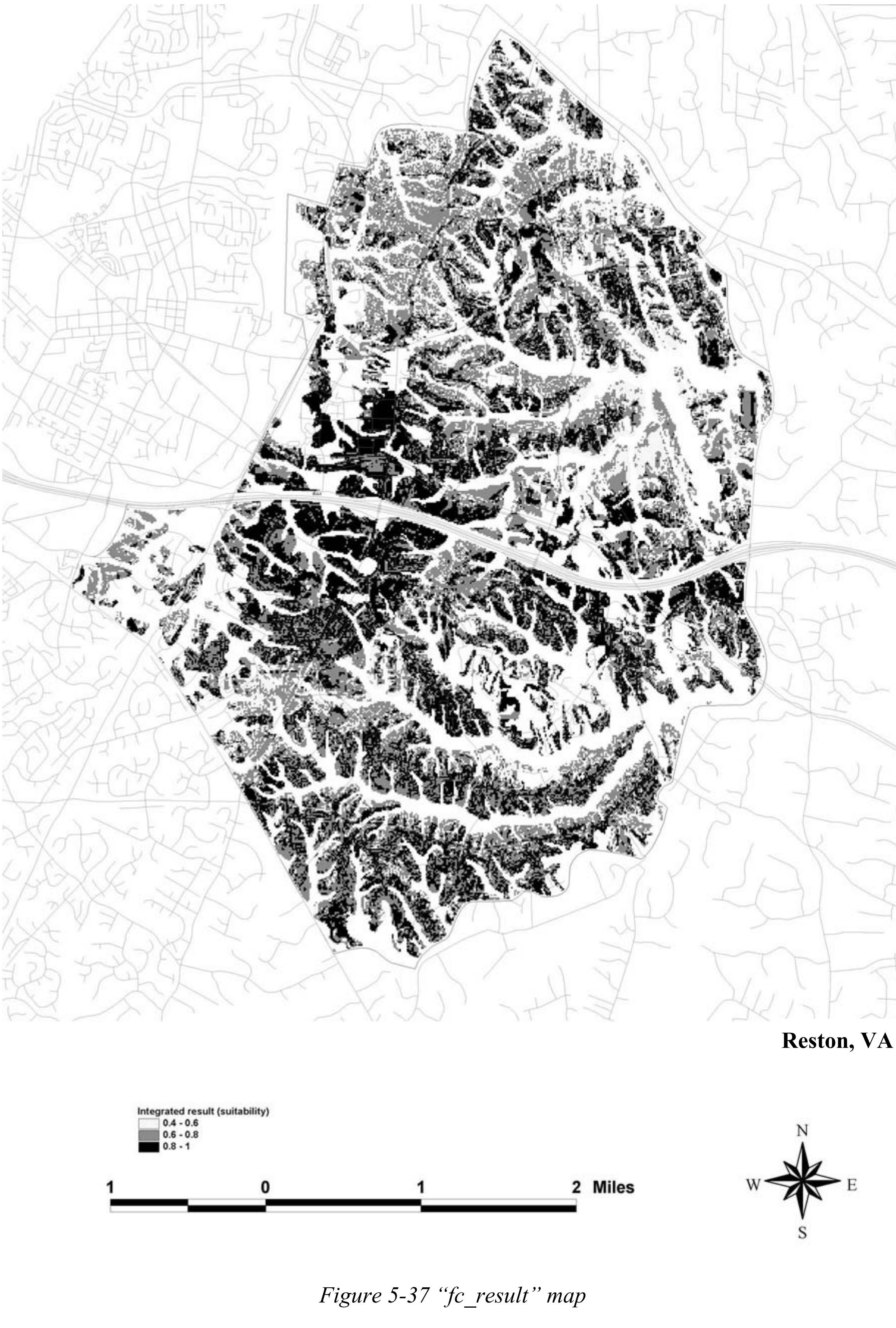


Figure 5-37 "fc_result" map